ARIANE 5

USER'S MANUAL

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ARIANE 5

User's Manual

Approved and issued

by

ARIANESPACE

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ARIANE 5

User's Manual

Preface

This document contains the technical information which is necessary:

a) to assess compatibilty of a spacecraft with the Ariane 5 launches,
b) to prepare all technical and operational documentation related to a launch of any spacecraft on Ariane 5.

This document will be revised periodically, comments and suggestions on all aspects of this manual will be encouraged and appreciated.

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FOREWORD

The ARIANE development program is carried out under the aegis of the European Space Agency (ESA) and under the management of the French Centre National d'Etudes Spatiales (CNES).

It is financed by the following participating European states: Austria, Belgium, Denmark, France, Germany, Ireland,Italy, the Netherlands, Norway, Spain, Sweden, Switzerland.

Following a decision by the participating States and a convention between the European Space Agency and ARIANESPACE, the responsibility for the production, financing, marketing and launching of operational Ariane vehicles and their uprated versions is entrusted to ARIANESPACE.

FOREWORD
(cont'd)

I – A PRIVATE COMPANY

ARIANESPACE is a French **Joint Stock Company** ("Société Anonyme") which was incorporated on March 26th 1980. Its authorized capital amounts to 270 millions French Francs.

The 52 sharehold partners in ARIANESPACE represent the scientific, technical, financial and political capabilities of **11 European countries** (Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, Switzerland and United Kingdom).

In order to meet the market needs, ARIANESPACE has established a worldwide presence: in Europe, with it head office located at Evry near Paris, France, in North America with Arianespace Inc., its subsidiary in Washington D.C., and in the Pacific Region, with its representative offices in Tokyo (Japan) and Singapore.

II – A RESPONSIBLE COMPANY

ARIANESPACE has adopted the structure of a commercial and engineering company fully responsible for financial results, in order to provide three main functions:

① **MARKETING AND SALES OF SATELLITE LAUNCH SERVICES** to all customers throughout the world,

② **PRIME CONTRACTOR RESPONSIBILITIES FOR ACTUAL PRODUCTION AND FINANCING** on operational ARIANE launch vehicles;

③ **OPERATIONS DIRECTORATE** using the Ariane launch site at the Guiana Space Center.

III – A SERVICE COMPANY

Arianespace's objective is to provide a complete, personalized service, covering the entire period from initiate formulation of the project with the customer and its satellite manufacturer, up to the launch.

This objective is achieved by the combination of a product such as the Ariane Launcher, fully automatic and optimized for this type of mission, and a modern launch complex equipped with all the facilities required for the preparation and testing of the latest generation of satellites, and manned by skilled technicians and engineers used to working with the latest state of the art technology.

In the area of insurance, ARIANESPACE created the subsidiary S.3.R. which provide additional insurance capacity to aid its clients with coverage during the launch phase.

User's Manual Configuration Control Sheet

ISSUE N° / Rev.	DATE	NEW SHEETS	APPROVAL
1	March 91	All	
2	May 94	All	
2/1	March 96	0.11 2.2, 2.3, 2.4, 2.5, 3.10, 3.15, 4.3, 4.5, 4.7, 4.9, 4.10, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6 8.12, 8.15, 8.16, 8.17 A3.1.1, A3.1.3, A3.1.4, A3.1.5, A3.1.6, A3.1.7, A3.2.4, A4.1.2, A4.1.4, A4.1.5, A4.1.6, A4.1.7, A4.1.9, A4.1.12, A4.1.13, A4.1.14, A4.1.15, A4.2.2, A4.2.4, A4.2.5, A4.2.6, A4.2.7, A4.2.9, A4.2.10, A4.2.11, A4.2.12, A4.2.13, A4.3.2, A4.3.4, A4.3.6, A4.3.7, A4.3.8, A4.3.10, A4.3.11, A4.3.12, A4.3.13, A4.4.2, A4.4.4, A4.4.5, A4.4.6, A4.4.7, A4.4.8, A4.4.9, A4.4.10, A4.4.11, A4.4.12, A4.4.13, A4.5.2, A4.5.4, A4.5.5, A4.5.6, A4.5.7, A4.5.8, A4.5.9, A4.5.10, A4.5.11	
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Abbreviations

ABM	Apogee Boost Motor (moteur d'apogée)
ACU	(payload adaptor) Adapteur Charge Utile
ACY	Raising Cylinder
AE	ARIANESPACE
AKM	Apogee Kick Motor (moteur d'apogée)
ARS	(satellite ground stations network assistant) Adjoint Réseau Stations Sol Satellite
ASE	(european space agency) Agence Spatiale Européenne
AZ	Azimuth – Azimut
BAF	(final assembly building) Bâtiment d'Assemblage Final
BCL	(launch vehicle checkout system) Banc de contrôle Lanceur
BCO	(operations coordination office) Bureau de Coordination des Opérations
BEAP	(solid propellant test bench) Banc d'Essais des propulseurs d'Appoint à Poudre
BIL	(launch vehicle integration building) Bâtiment d'Integration Lanceur
BNAe	(national office for standards in aeronautic) Bureau de Normalisation de l'Aéronautique
BNBD	(low-level bipolar unbalanced) Bas Niveau Bipolaire Dissymétrique
BNM	(national metrology office) Bureau National de Métrologie
BRCU	(payload interconnection bay) Baie de Répartition Charge Utile
BV	(flight plug) Bouchon de Vol
CCU	(payload container) Conteneur Charge Utile ARIANE
CDL	(launch centre) Centre de Lancement
CDR	Critical Design Review (revue critique de définition)
CG	(Center of Gravity) Centre de Gravité
CM	(mission director) Chef de Mission
CMP	(handling and protection ring) Couronne de Manutention et Protection
CNES	(french national space center) Centre National d'Etudes Spatiales
COC	(VEB command unit) Centrale d'Ordres Case
COEL	(launch site operations manager) Chef des Opérations Ensemble de Lancement
COTE	Check-Out Terminal Equipment (banc de contrôle)
CPAP	(ariane production project manager) Chef de Projet Ariane Production
CPS	(spacecraft project manager) Chef de Projet Satellite
CSEL	(launch complex safety officer) Chef Sauvegarde Ensemble de Lancement
CSG	(guiana space centre) Centre Spatial Guyanais
CU	(payload) Charge Utile
DAM	(mission analysis document) Dossier Analyse de Mission
DAMF	(final mission analysis document) Dossier Analyse de Mission Finale
DAMP	(preliminary mission analysis document) Dossier Analyse de Mission Préliminaire
DCA	(destruct command unit) boîtier de Destruction Commandée et Automatique
DCI	(interface control file) Dossier de Contrôle Interfaces
DDO	(range operations manager) Directeur d'Opération
DL	(launch requirements document) Demande de Lancement
DMS	(spacecraft mission director) Directeur de la Mission Satellite
DUA	(application to use Ariane) Demande d'Utilisation Ariane
DV	(flight director) Directeur de Vol
EDP	(hazardous primary circuits) Ensemble Dangereux Primaire
EDS	(hazardous secondary circuits) Ensemble Dangereux Secondaire

EGSE	Electrical Ground Support Equipment (équipements électriques de support sol)
ELA	(Ariane launch site) Ensemble de Lancement Ariane
EPCU	(payload preparation complex) Ensemble de Préparation Charge Utile
EPS	(storable propellant stage) Etage à Propergol Stockable
ESA	European Space Agency (agence spatiale européenne)
ESC	(cryogenic upper stage) Etage Supérieure Cryotechnique
ESMC	Eastern Space Missile Center
FM	Frequency Modulation (modulation de fréquence)
GAM/GAT	(motor and thruster activation system) Groupe d'Activation Moteur/Tuyères
GSE	Ground Support Equipement (équipements de support sol)
GTO	Geostationary Transfer Orbit (orbite de transfer géostationnaire)
H155	Cryogenic main core (étage principal cryogénique)
HEO	Highly Elliptical Orbit
HNBD	(hight-level bipolar unbalanced) Haut Niveau Bipolaire Dissymétrique
HNMD	(hight-level unipolar unbalanced) Haut Niveau Monopolaire Dissymétrique
HV	Hight Voltage (haute tension)
ISCU	(payload safety officier) Ingénieur Sauvegarde Charge Utile
ISLA	(launch area safety officer) Ingénieur Sauvegarde ensemble de Lancement
KM	Kick Motor (moteur d'appoint)
KRU	Kourou
L/V	Launch Vehicle (lanceur)
L9	Storable propellant stage
LAM	(measuring instrument laboratory) Laboratoire d'Appareils de Mesures
LBC	(check out equipment room) Local Banc de Contrôle
LCCD	Linear Charge Cord Device (système de découpe par tube à expansion)
LEO	Low Earth Orbit (orbite basse)
LTD	Liaisons Transmission de Données (data transmission links)
LW	Launch Window (fenêtre de lancement)
MCI	(masses alignment and inertias) Masses Centrages et interties
MCU	(payload mass) Masse Charge Utile
MEO	Medium Earth Orbit
MEOP	Maximum Expected Operating Pressure (pression maximale prévue en fonctionnement)
MGSE	Mechanical Ground Support Equipment (équipements mécaniques de support sol)
MM	Mission Manager (ingénieur d'affaire)
Mo	mean anomaly – anomalie moyenne
MUA	(Ariane user's manual) Manuel Utilisateur Ariane
NA	Not Applicable – Non Applicable
OBC	On Board Computer (calculateur embarqué)
OCOE	Overall Check Out Equipment (banc de contrôle principal)
P230	Solid propellant booster (propulseur d'appoint à poudre)
PA	(acoustic blanket) Protection Acoustique
PAL	(liquid propellants strap-on booster) Propulseur d'Appoint à Liquides
PAP	(solid propellant strap-on booster) Propulseur d'Appoint à Poudre
PCM	Pulse Coded Modulation
PCU	(payload console) Pupitre Charge Utile
PDE	Pressurization/Depressurization Equipment (équipement de pressurisation-dépressurisation)
PDR	Preliminary Design Review (revue de définition préliminaire)
PFCU	(payload platform) Plate Forme Charge Utile

PFT	(transport platform) Plate Forme de Transport (du CCU)
PIP	(Pyro Interception Plug) Prise d'Interception Pyrotechnique
POC	(combined operations plan) Plan des Opérations Combinées S/C + L/V
POE	(electrical umbilical plug) Prise Ombilicale Electrique
POI	(interleaved spacecraft operations Plan) Plan des Opérations satellite Imbriquées
POP	(pneumatic umbilical plug) Prise Ombilicale Pneumatique
POS	(spacecraft operations plan) Plan des Operations Satellite
PPLS	Propellant and Pressurant Loading Systems (chariot de remplissage et pressurisation ergols)
PSCU	(payload safety console) Pupitre Sauvegarde Charge Utile
QSL	Quasi Static Load (charge quasi statique) equivalent to load factor
RAL	(launch readiness review) Revue d'Aptitude au Lancement
RAM	(mission analysis review) Revue d'Analyse de Mission
RAMF	(final mission analysis review) Revue d'Analyse de Mission Finale
RAMP	(preliminary mission analysis review) Revue d'Analyse de Mission Préliminaire
RAVL	(launch-vehicle flight readiness review) Revue d'Aptitude au Vol du Lanceur
RAVS	(satellite flight readiness review) Revue d'Aptitude au Vol du Satellite
RC	Remote Console (baie de contrôle)
RF	Radio Frequency (Radio Fréquence)
rpm	Revolution per minute (tour par minute)
rms	root mean square
RN	(national road) Route Nationale
RPS	(spacecraft preparation manager) Responsable Préparation Satellite
RS	(safety manager) Responsable Sauvegarde
RSG	(ground safety officier) Responsable Sauvegarde Sol
RSV	(flight safety officier) Responsable Sauvegarde Vol
RTW	Radio Transparent Window (fenêtre radio transparente)
S/C	Spacecraft (satellite)
S1	builidings S1 (spacecraft preparation) – bâtiments S1 (préparation satellite)
S2	buildings S2 (SPM preparation) – bâtiments S2 (préparation moteur d'appoint à poudre)
S3	buildings S3 (spacecraft filling and assembly) – bâtiments S3 (assemblage, remplissage, satellite)
S4	building S4 (SPM X-Ray) - bâtiment S4 (radiographie rayons X)
SCA	(attitude control system) Système de Contrôle d'Attitude
SCOE	Special Check Out Equipment (banc de contrôle secondaire)
SIW	Satellite Injection Window (fenêtre d'injection satellite)
SPELTRA	(Ariane external carrying structure for triple launch) Structure Porteuse Externe Lancement Triple ARIANE
SPM	Solid Propellant Motor (moteur à poudre)
SSO	Sun Synchronous Orbit (orbite heliosynchrome)
SYLDA 5	Dual Launch System for AR.5 (Système Lancement Double AR.5)
TBD	To Be Defined (à définir)
TC	TeleCommand (TéléCommande)
TM	TeleMetry (TéléMesure)
TO	Transfer Orbit (orbite de transfer)
UA	(acquisition unit) Unité d'Acquisition
UDMH	Unsymmetrical DiMethyl Hydazine (diméthyl hydrazine dissymétrique)
UT	Universal Time (Temps universel)
VEB	Vehicle Equipment Bay (case à équipements Ariane)
Za	(apogee altitude) altitude de l'apogée
ZA	(Ariane assembly area) Zone d'Assemblage Ariane
ZES	(storable propellant area) Zone Ergols Stockables
ZL	(Ariane launch site) Zone de Lancement Ariane

ZP	(protected pad) Zone Protégée
ZP	(Ariane preparation zone) Zone de Préparation
ZSE	(propellant storage area) Zone Support Ergols
ZSP	(solid propellant storage area) Zone de Stockage des Propulseurs
a	Semi-major axis – demi grand axe
e	Eccentricity – Excentricité
i	Inclination – Inclinaison
ω	argument of perigee – argument du périgée
Ω	ascending node – nœud ascendant
ΩD	descending node –nœud Descendant
Zp	perigee altitude – altitude du périgée

Introduction Chapter 1

1.1. Purpose of the User's manual

This manual is intended to provide Users with information of the Ariane 5 series of launch vehicles.

The reader should also refer to the "C.S.G. Safety Regulations" which is applicable for spacecraft design and operations and the "Payload Preparation Complex (E.P.C.U.) Manual" (CD-ROM).

The above three documents constitute the Ariane technical reference documentation used for the Ariane-spacecraft feasibility phase studies. On completion of the feasibility phase, formal documentation will be established in accordance with the procedures outlined in Chapter 6 of this manual.

1.2. The Ariane 5 launch system

Arianespace offers a complete launch system including the vehicle, the launch facilities and the associated services.

The *launch vehicle* is basically the Ariane two-stage-vehicle with solid strap on boosters. Depending on the required performance and the composition of its payload, one of several launch configurations can be selected by Arianespace based upon the utilization of different upper stages (storable propellant or cryogenic) and dual launch systems. These configurations are described in paragraph 1.3.

The *launch facilities* located in French Guiana comprise the Payload Preparation Complex EPCU and the Ariane Launch Complex ELA 3.

Arianespace is organized to offer a *Launch Service* based on a continuous interchange of information between a Spacecraft Interface Manager (User), and the Ariane Mission Manager (Arianespace) who are appointed at the time of the launch contract signature. As from that date, the Ariane Mission Manager is responsible for the execution of the Launch Service Contract. For a given launch, therefore, there are one or two Spacecraft Interface Manager(s) and one or two Arianespace Mission Manager(s), depending on whether the launch is a single or a dual one.

For the preparation and execution of the Guiana operations, the Ariane launch team is managed by a specially assigned Mission Director who will work directly with the User's operational team.

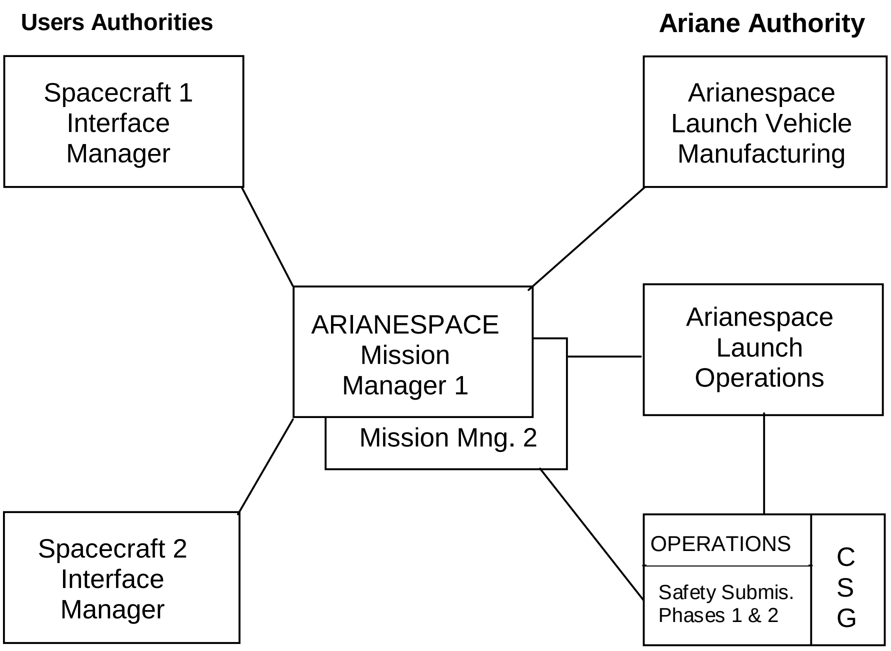


Fig. 1.1 – Principle of Users / Arianespace Relationship

1.3. The Ariane-5 general characteristics

Ariane 5 consists of a lower section designed for automatic and originallymanned missions and an upper section with different mission-dependent possible configurations.

1.3.1. Lower section

The lower section is composed of the cryogenic main core and the two solid strap-on boosters.

The cryogenic main core is characterized by its huge 23.8 meters long tank, containing the liquid oxygen and liquid hydrogen propellants, which feed the single Vulcain or Vulcain 2 engine.

The engine is ignited and checked (and shut down if pamareters are not nominal) a few seconds before the strap-on solid boosters are ignited on an irreversible operation.

After completing its mission, the stage continues its own ballistic trajectory during which it is rotated to ensure a natural and safe fall in the ocean.

The solid rocket boosters provide more than 90 % of the thrust at lift off. The thrust is transmitted to the core stage via the forward attachment device. The boosters are jettisoned when the inertial unit detects thrust tail-off.

They are composed of three segments, rear and middle of about 105 tons each, forward of about 20 tons. The stainless steel case is made of seven flow formed cylindrical sections.

Main characteristics:

	Solid boosters	Main cryogenic core	
		Generic	Evolution
Combustion time	~ 130 s	~ 600 s	~ 600 s
Vacuum thrust	5000 kN each	1100 kN	1350 kN
Length	31.2	30.5	30.5
Diameter	3	5.4	5.4
Propellant mass	237 tons	158 tons	170 tons
Total mass	268 tons	170 tons	182 tons

1.3.2. Upper section

The upper section consists of the upper stage, the Vehice Equipment Bay (VEB), and the payload compartment.

The Vehicle Equipment Bay houses the hydrazine flight control system, inertial guidance instrumentation, range safety, tracking and power systems.

The Ariane 5 launch vehicle has two basic spacecraft compartment configurations, one for single spacecraft launches and one for dual spacecraft launches:

- Single launch.

Fairings available:
Short fairing: 12.7 m high,
Medium fairing: 13.7 m high,
Long fairing: 17 m high,
A ∅ 5400 m cylindrical structure which height varies from 500 mm to 2000 mm can be used to lengthen the short or medium fairing.

- Dual launch.

Fairings available:
Short fairing: 12.7 m high,
Medium fairing: 13.7 m high,
Long fairing: 17 m high,

For dual launches either the SPELTRA or SYLDA 5 carrying structure will be used (see Figure 1.3.b).

A ∅ 5 400 mm cylindral structure which height varies from 500 mm to 2000 mm can be used to lengthen the short or medium fairing, or the SYLDA or SPELTRA.

SPELTRA is mounted above the upper stage. It surrounds the inner spacecraft and supports the upper spacecraft and the fairing.

Two types of SPELTRA are available:

- SPELTRA 4160 : 5,5 m high,
- SPELTRA 5560 : 7 m high.

SYLDA 5 is available in 6 versions from the Standard SYLDA 5, 4.9 m high, to the Long SYLDA 5, 6.4 m, high by steps of extension length of 300 mm.

The upper stage can be:
- Either a storable propellant upper stage (EPS) with the engine reignition capability allowing coast phase.

- Or a cryogenic upper stage (ESC). The ESC-A is powered by the Ariane 4 HM7B engine used on the Ariane 4 launch vehicle. ESC-B will be powered by the VINCI engine in development.

EPS characteristics:

Propellants	MMH / N_2O_4
Engine Vacuum thrust	29 kN
Vacuum specific impulse	321 s
Propellant loading	AR5G: 9 700 kg AR5E: 10 000 kg
Total mass	AR5G: 10 900 kg AR5E: 11 200 Kkg

ESC characteristics:

	ESC-A	ESC-B
Engine	HM7B	VINCI
Propellant	LOX+LH_2	LOX+LH_2
Propellant loading	14 tons	25 tons
Engine vacuum thrust	63 kN	150 kN
Engine specific impulse	446 s	466 s
Number of ignition	1	1 to 5
Technology	Gas generator	Expander cycle

The Ariane 5 general layout is shown on figure 1.3.1, figure 1.3.2 illustrates possible payload composite configurations.

1.4. Ariane 5 Launch Family

Arianespace continually develops solutions that meet evolving customer demand. Priority is given to provide access to space for all space applications under the best conditions. Ariane 5 evolutions will provide an increased payload carrying capacity, a flexibility to perform a wide range of missions with the high reliability demonstrated throughout the Ariane program.
Thanks to the upgrades that increase the GTO capacity, Ariane's baseline mission continues to be the dual satellite launch, which is the best way to optimize the cost/performance ratio.

The Ariane 5 family (see fig. 1.4.a) includes the ARIANE 5 G currently operated and which performance increases as the launch system matures.
The ARIANE 5 E is based on an evolution of the VULCAIN engine that powers the cryogenic core stage. This evolution, called VULCAIN 2 will provide an increased thrust through an overall mixture ratio and liquid oxygen mass flow increase.

The additional propellant loading is possible with no modification of the stage length, but only a shifting of the common bulkhead inside the tank.
A comparison between the VULCAIN and VULCAIN 2 is given in the table below:

	VULCAIN	VULCAIN 2
Propellant mass (t)	155	170
Vacuum thrust (kN)	1145	1350
Mixture vatio	5.3	6.1
Vacuum specific impulse (sec)	431.2	431.2

Ariane 5E will also benefit of various enhancements such as carbon fiber Vehicle Equipment Bay, that will also incorporate a new separation system generating a lower shock level.

Two upper stages can be flown as part of the Ariane 5E configuration.

- Either the storable propellant upper stage with the reignition capability. This option will be provided through a "kit", installed on the launch vehicle if the mission requires this function (A5ES)
- Or a cryogenic stage, powered by the Ariane 4 HM7B cryogenic engine. Making use of an existing, reliable engine allows to shorten the development schedule and limits the development risks. A5ECA: Ariane 5E with cryogenic upper stage Type A.

A new cryogenic engine (VINCI) in development will allow to further increase the performance, while providing reignition capability. A5ECB: Ariane 5E with cryogenic upper stage type B.

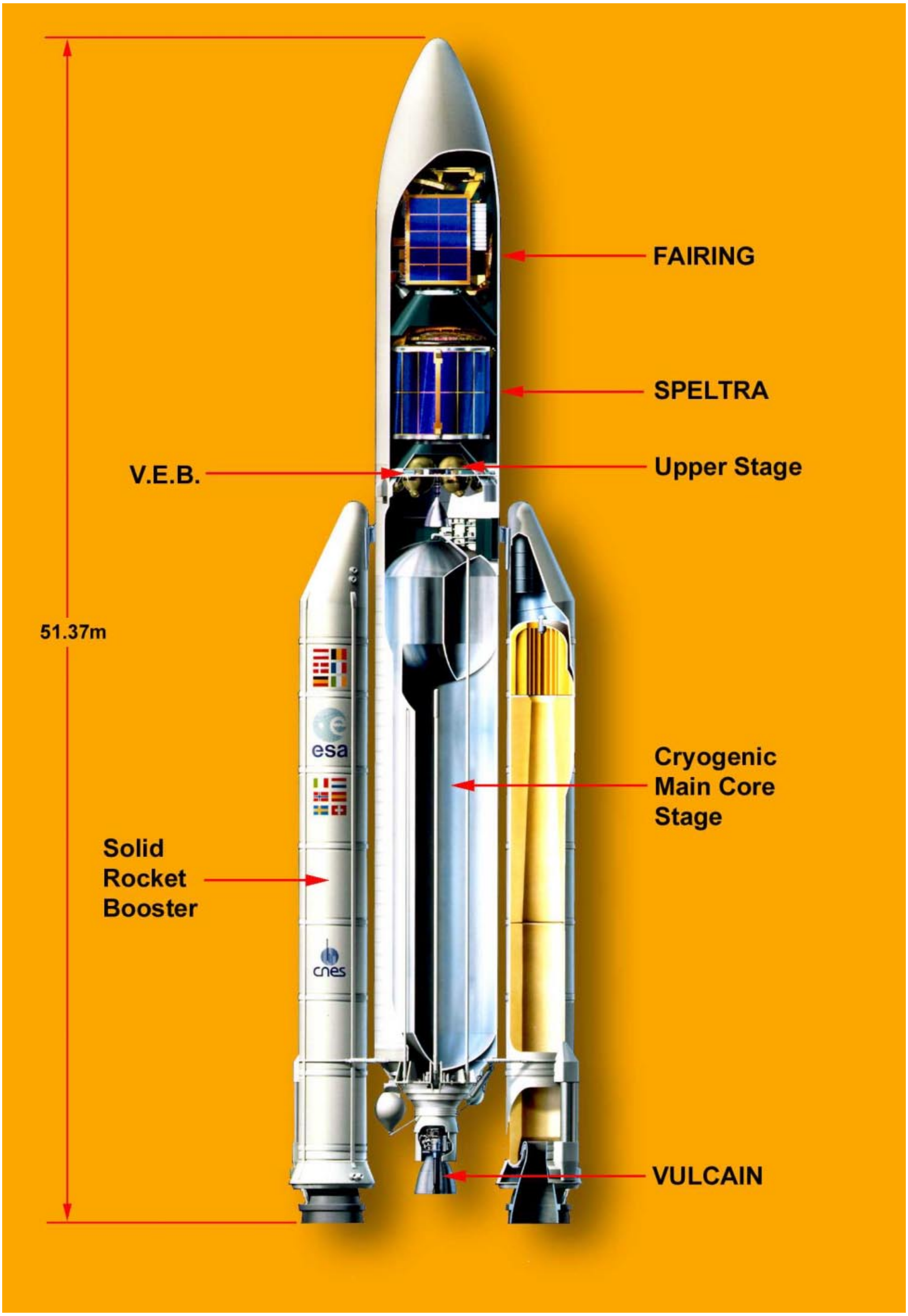


Fig. 1.3.a - Ariane 5 General Layout

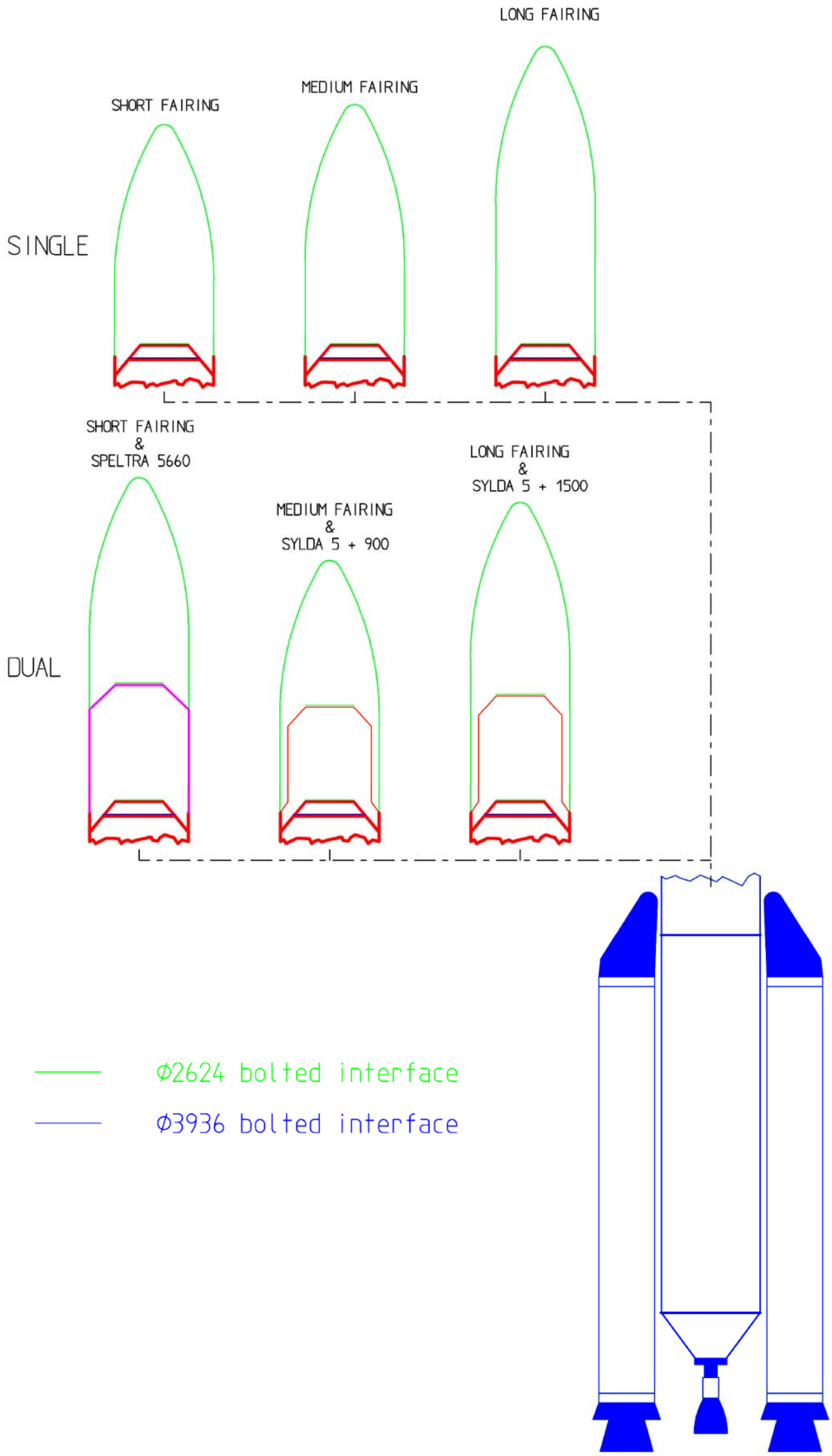


Fig. 1.3.b – Ariane 5 Typical Payload Compartment Configurations

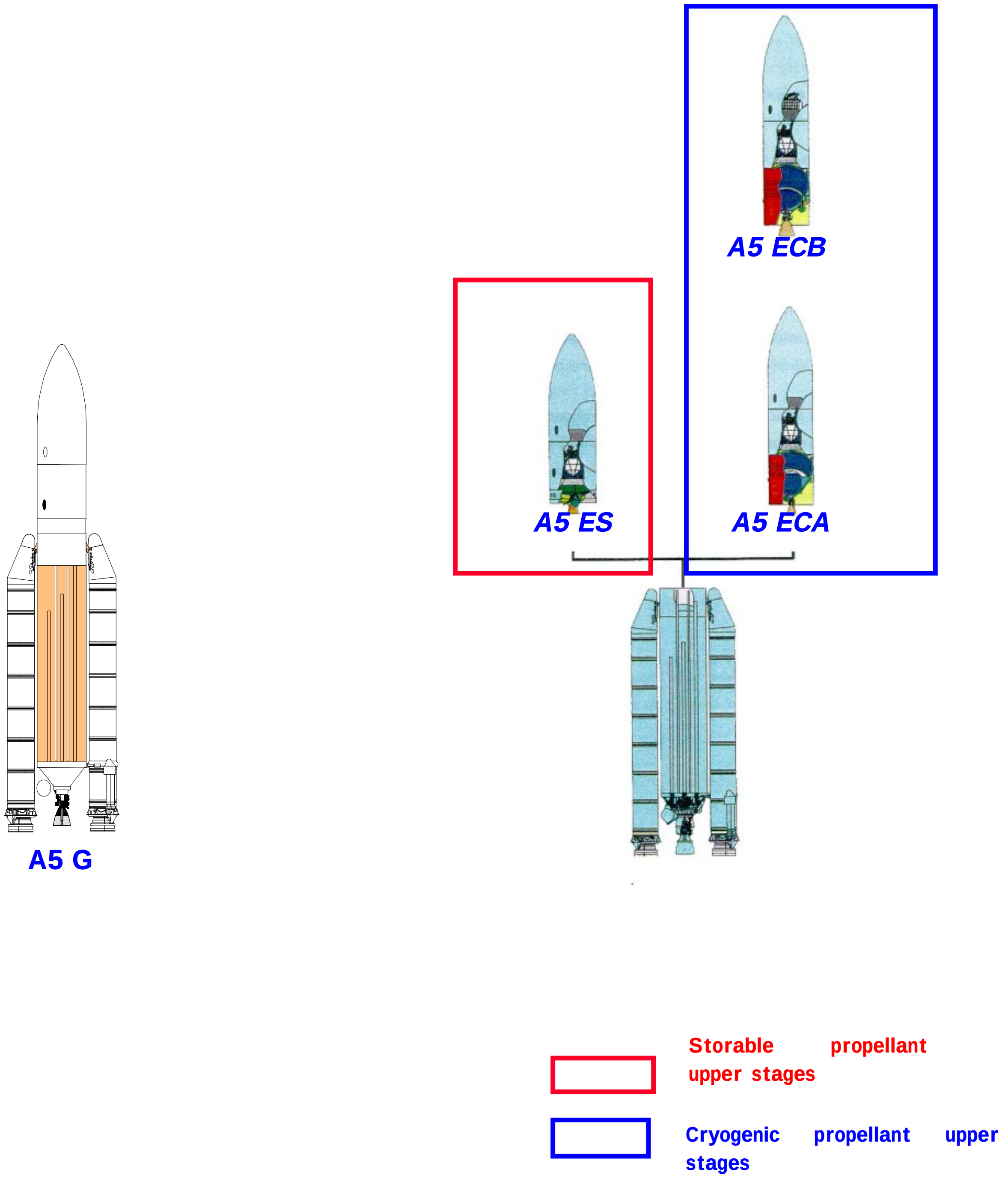


Fig. 1.4.a – Ariane 5 Launch Vehicle Family

General performance data — Chapter 2

2.1. Introduction

This section provides the information necessary to make preliminary performance assessments for the launch vehicles of the ARIANE 5 family.

Performance data are given for ARIANE 5 G (Generic) corresponding to the vehicles of the first production batch (16), as well as for the ARIANE 5 E (Evolution) with either the storable propellant upper stage (A5 ES) or cryogenic propellant upper stage (A5 ECA).

This document is a guide for mission design, and predictions are presented with a slight degree of conservatism to make sure that the launch vehicle will meet the expectations.

Beyond these performance figures, customized and innovative methods and solutions can also be proposed to Customers, to individually optimize their mission or even increase the launch vehicle standard capability.

ARIANE 5 can perform the launch in single payload configuration. This allows to specifically tailor the mission to the customer needs. Through the use of various carrying structures, dual launches can also be performed. This has demonstrated throughout many years to be a unique way to rapidly and economically deploy satellites onto the geostationary transfer orbit.

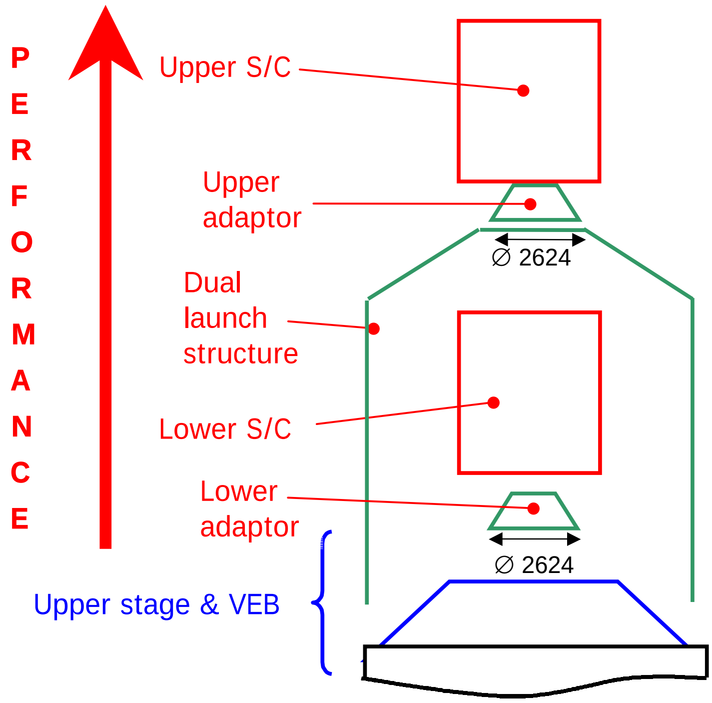
Multiple payload deployment can be achieved by means of dispensers described in the annexes.

2.2. Performance definition

The performance figures given in this chapter are expressed in terms of payload mass. The mission performance includes the mass of:

- the spacecraft(s),
- the dual launch system (if used), which mass is mission dependant and approximately of:
  - SYLDA 5 425 kg
  - SYLDA 5 + 900 mm 470 kg
  - SYLDA 5 + 1500 mm 500 kg
  - SPELTRA 4160 716 kg
  - SPELTRA 5660 822 kg
- the adaptors or dispensers: adaptors masses are defined in the appendices,
- the raising ∅ 5400 cylindrical structure (if used)

  H = 500 mm m = 134 kg
  H = 1 000 mm m = 173 kg
  H = 1 500 mm m = 212 kg
  H = 2 000 mm m = 250 kg



Performance computations are based on the following main assumptions:

- Cryogenic main core and upper stage carrying sufficient propellant to reach the targeted orbit with the specified probability of 99% except otherwise specified.
- Aerothermal flux at fairing jettison and second aerothermal flux less or equal to 1135 W/m^2
- Altitude values given with respect to a spherical earth radius of 6378 km.
- Launch from the CSG (French Guiana), taking into account the relevant safety requirements.

2.3. ARIANE 5G

2.3.1. Geosynchronous transfer performance

2.3.1.1. Ariane 5G standard Geostationary Transfer Orbit (GTO)

Most of the communications satellites in orbit have been launched by ARIANE into the Geostationary Transfer Orbit (GTO). These satellites have benefited of the unique location of the Kourou Europe Spaceport: its low latitude minimizes the satellite on-board propellant needed to reach the equatorial plane. Based on the satellite constraints, the resulting optimized dual launch ARIANE 5 standard Geostationary Transfer Orbit, defined in terms of osculating parameters at injection, is:

- Inclination i = 7 deg
- Altitude of perigee Zp = 560 km
- Altitude of apogee Za = 35 890 km
- Argument of perigee ωp = 178 deg

Injection is defined as the end of upper stage thrust-decay.
Za is equivalent to true altitude 35 786 km at first apogee.
The longitude of the first descending node Ω, as defined in the figure 2.3.1.a usually lies around 10 deg West.

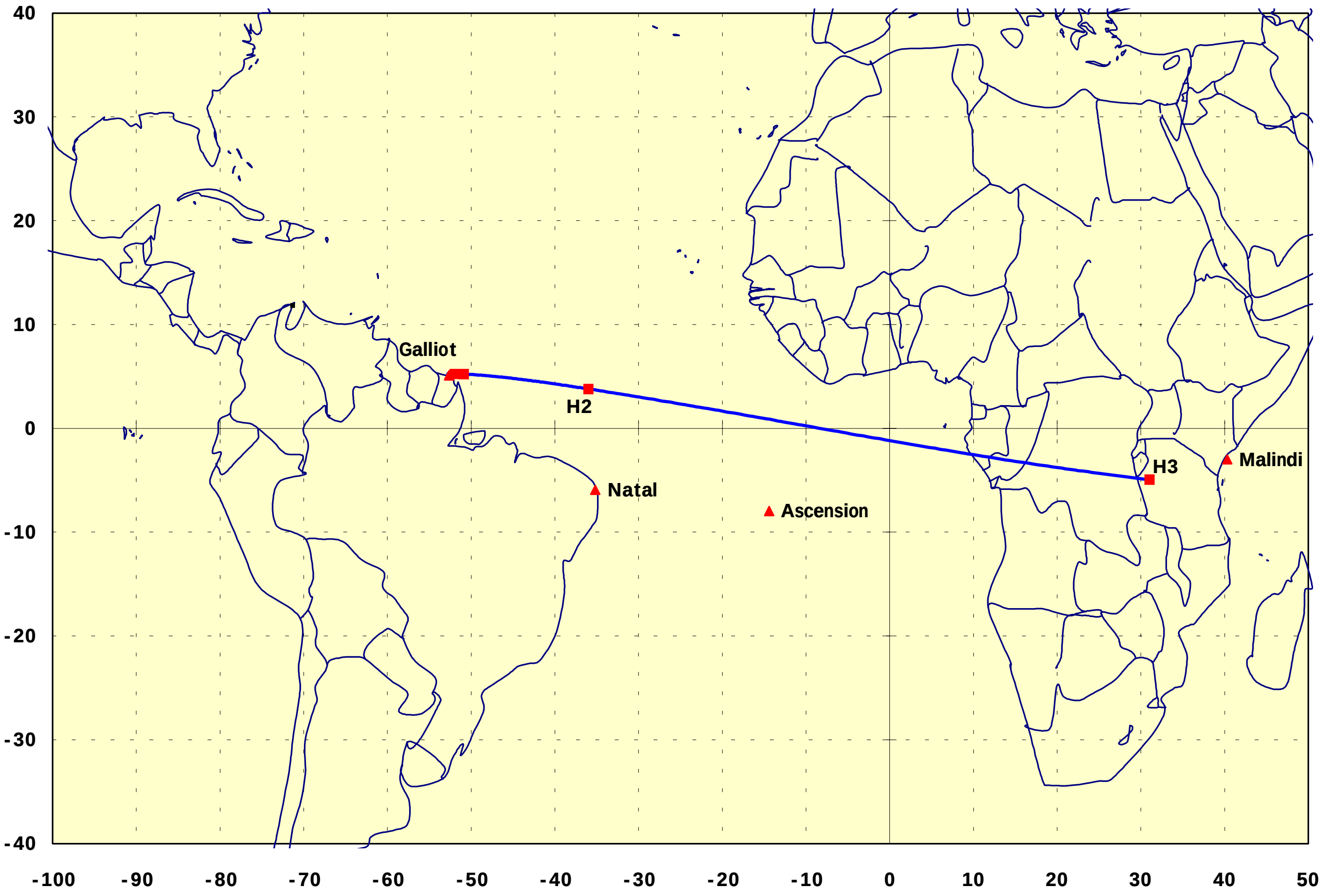


Figure 2.3.1.a - Typical Ground Track

2.3.1.2. Performance on the standard Geostationary Transfer Orbit

The ARIANE 5 G performance is **6640 kg**.

2.3.1.3. Injection Accuracy

The following table gives the typical standard deviation values (1 sigma):

a	semi major axis	40
e	excentricity	4.10^{-4}
i	inclination (deg)	0.02
ωp	argument of perigee (deg)	0.15
Ω	Ascending node (deg)	0.15

2.3.1.4. Typical launch vehicle trajectory

Figures 2.3.1.b and 2.3.1.c show the main trajectory parameters as a function of flight time.

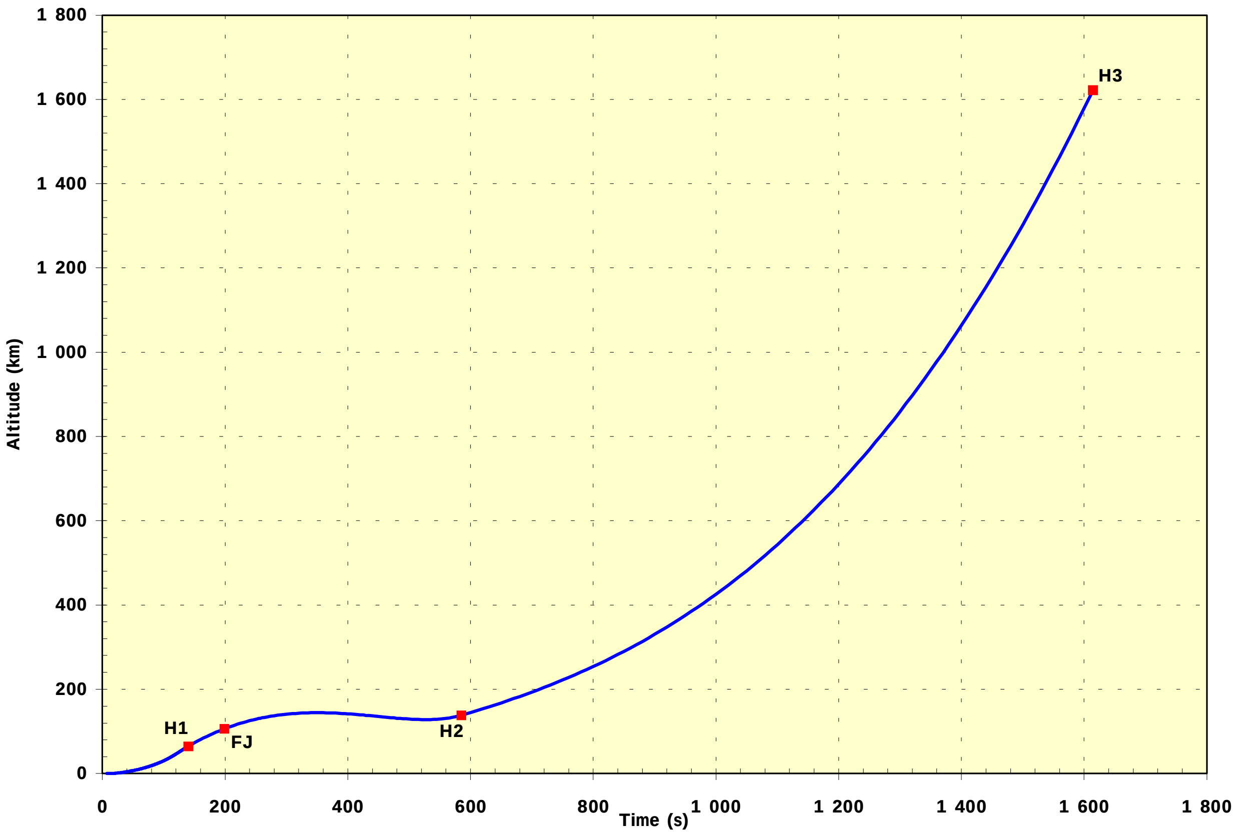


Figure 2.3.1.b – Ariane 5G Trajectory – Altitude Versus Time

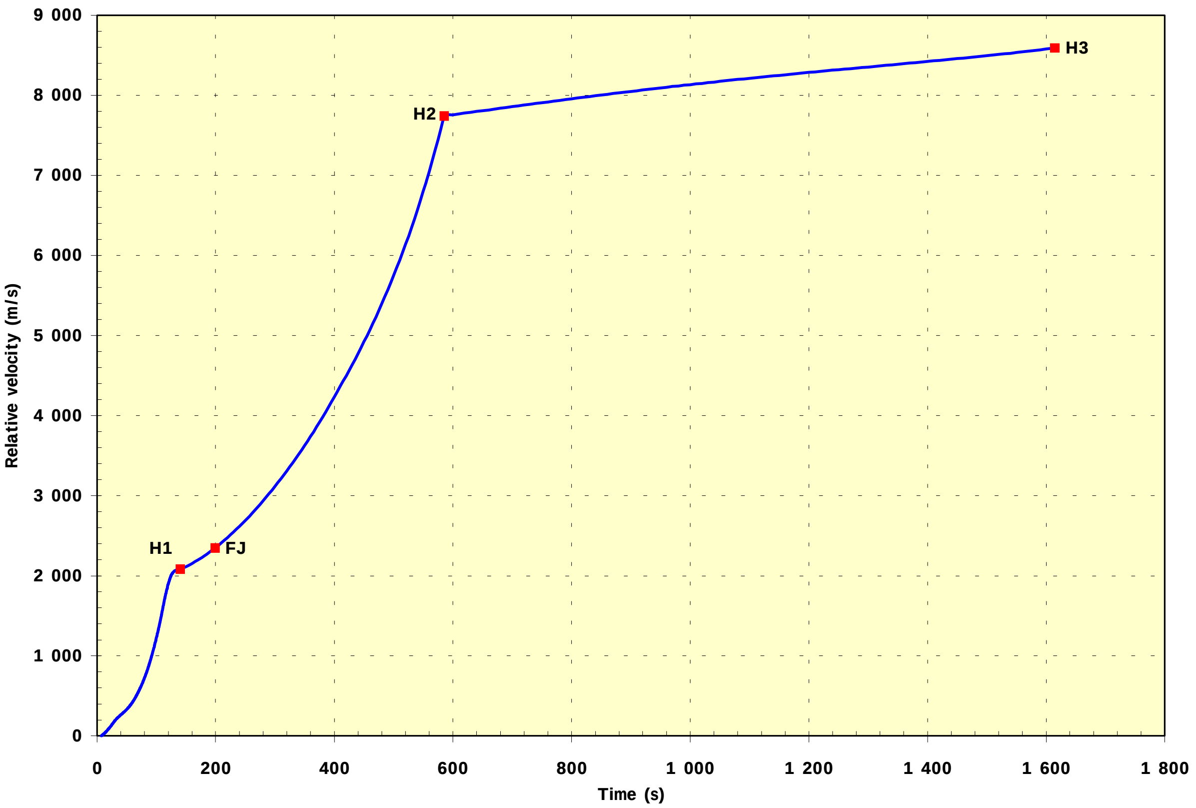


Figure 2.3.1.c – Ariane 5G Trajectory – Relative Velocity Versus Time

2.3.2. Optimized geosynchronous transfer injection

The GTO performance can be increased by performing a ballistic phase between the main core stage / upper stage separation and the upper stage ignition.
This coast phase of approximately 4 500 s allows to increase the performance by about 200 kg.
The injection orbit is then:

- Inclination i = 7 deg
- Altitude of perigee 200 km ≤ Zp ≤ 300 km
- Altitude of apogee Za = 35 930 km
- Argument of perigee ωp = 358 deg
- Ascending node longitude lies around 150 deg East.

The coast phase duration and perigee altitude are defined to optimize the performance gain.
For further information on this strategy please, contact ARIANESPACE.

2.3.3. Tailored GTO mission

Although the ARIANE 5 standard Geostationary Transfer Orbit, with its low inclination, does already provide a good answer to achieve the lifetime requirement of the Customer, Arianespace can propose a wide range of options to further increase the spacecraft beginning of life propellant mass and Customer's revenue.

The ARIANE mission can be customized by some adjustments to the transfer orbit.

2.3.3.1. Aerothermal flux

Aerothermal flux after fairing jettisoning can be set differently from the standard. The figures 2.3.3.1.a and 2.3.3.1.b show the influence on the performance. The "zero" reference corresponds to the standard 1135 W/m^2 value. Increasing this value allow to increase the final launch vehicle performance.

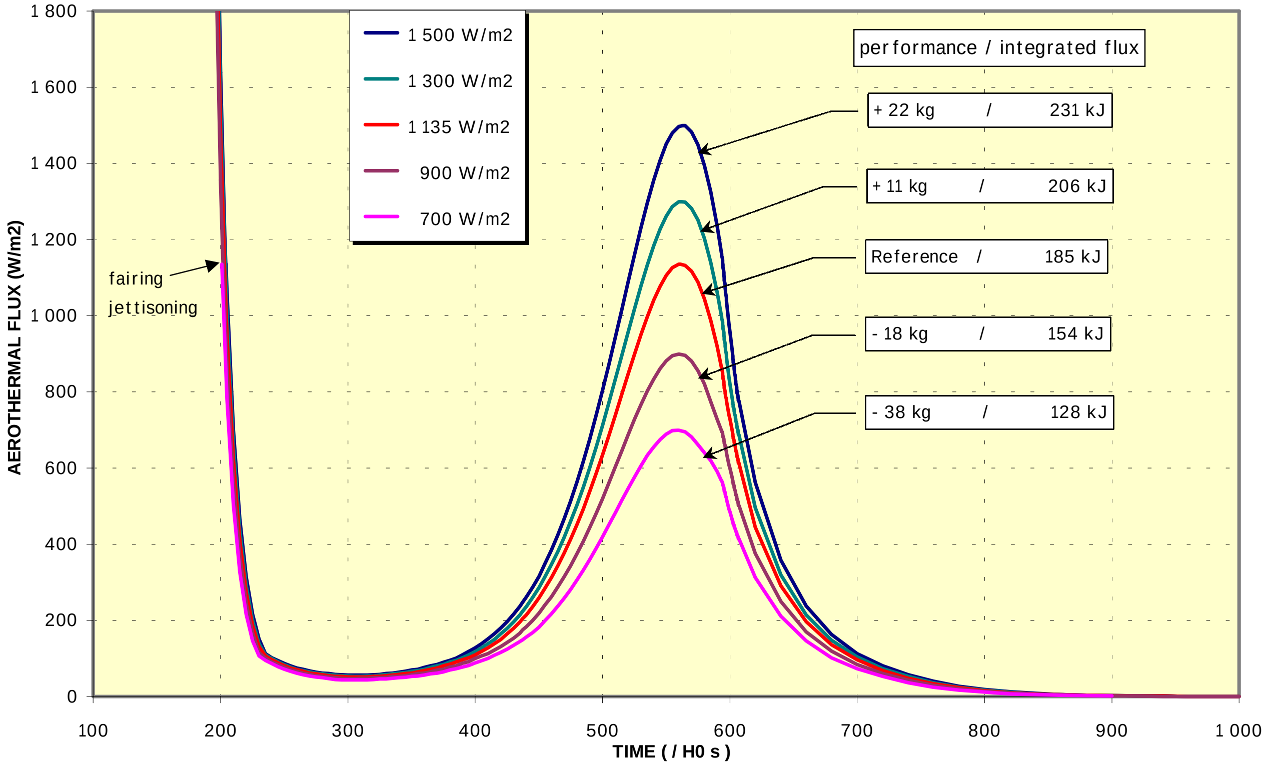


Figure 2.3.3.1.a – Impact of Aerothermal Flux on Performance

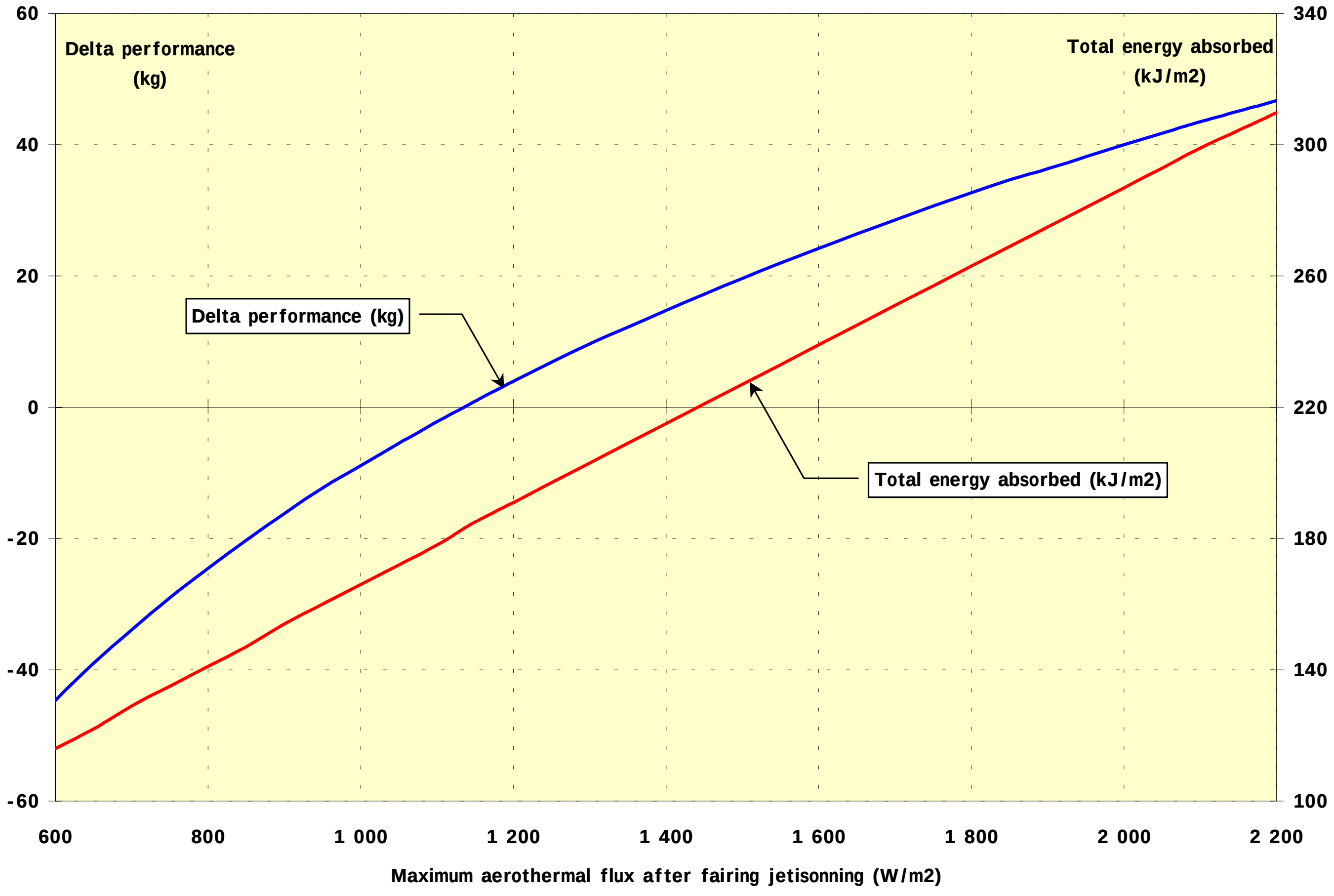


Figure 2.3.3.1.b – Impact of Aerothermal Flux on Performance

2.3.3.2. Argument of perigee and inclination adaptation

This launch strategy can be proposed when the spacecraft mass is below the standard GTO performance of the launcher. Spacecraft lifetime can be increased by furthermore reducing the transfer orbit inclination. The spacecraft propellant mass necessary to circularize the orbit and lower the inclination is accordingly reduced for the benefit of the spacecraft lifetime.

The curve 2.3.3.2.a presents the launch vehicle Δ performance for inclination ranging from 1 to 7 deg.

Argument of perigee and inclination can also be optimized to customer needs. The curve 2.3.3.2.b shows the Δ performance impact for inclinations from 1 to 7 deg and argument of perigee from 25 to 215 deg.

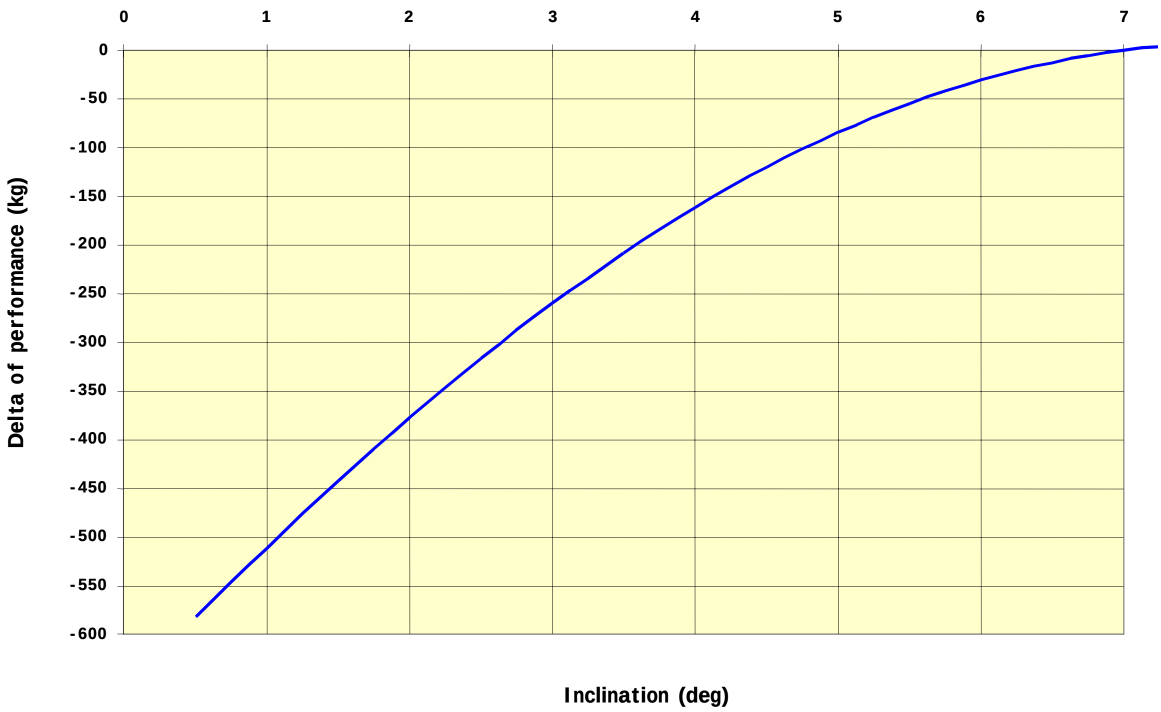


Figure 2.3.3.2.a – Performance Versus Inclination

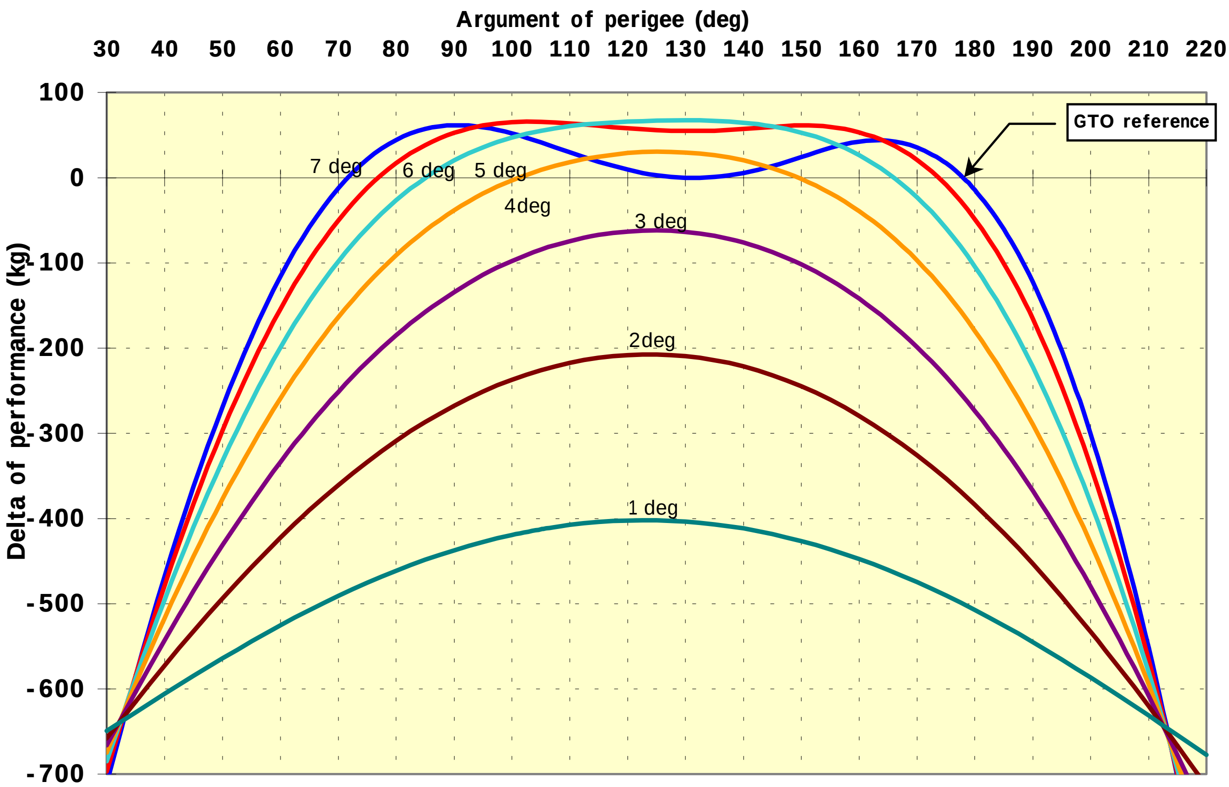


Figure 2.3.3.2.b – Performance Versus Argument of Perigee and Inclination

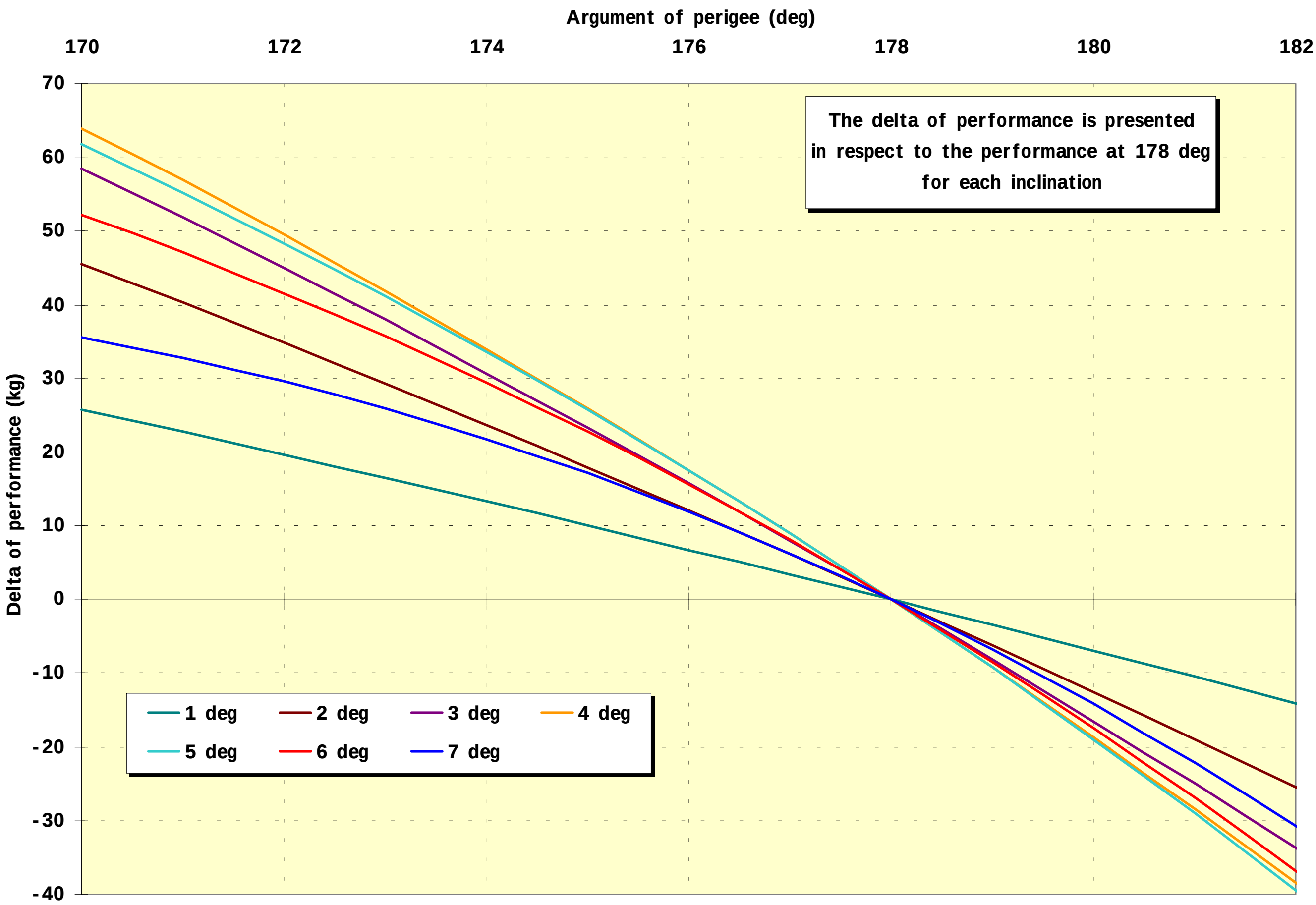


Figure 2.3.3.2.c – Performance Versus Argument of Perigee

2.3.3.3. Supersynchronous transfer

Supersynchronous transfer can be proposed when the spacecraft mass is below the standard GTO performance. Spacecraft lifetime can be increased by reducing the propellant needed to circularize the orbit and lower the inclination. These maneuvers are performed at a higher than geosynchronous altitude, where the velocity is decreased. The curves on figure 2.3.3.3.a present the ARIANE 5 ∆performance for apogee altitude ranging from 36 000 to 60 000 km. The others parameters of the orbit remain unchanged.

2.3.3.4. Subsynchronous transfer

Subsynchronous transfer consists in injecting the spacecraft on a transfer orbit with an apogee lower than geosynchronous. The ARIANE 5 ∆performance curves for apogee altitude between 20 000 km and 36 000 km are presented in figure 2.3.3.3.a. This strategy is of interest when the satellite mass exceeds the launch vehicle performance on the standard GTO and when the spacecraft tank capacity is large with respect to the standard GTO injection and lifetime needs. The spacecraft propulsion system is used at the perigee of the transfer orbit to raise the apogee, this maneuver being known as the Perigee Velocity Augmentation (PVA). The overall propulsion budget of the mission translates in a benefit for the spacecraft in terms of lifetime (for a given dry-mass) or in terms of dry mass (for a given lifetime) compared to the standard GTO injection limited to the launch vehicle capability.

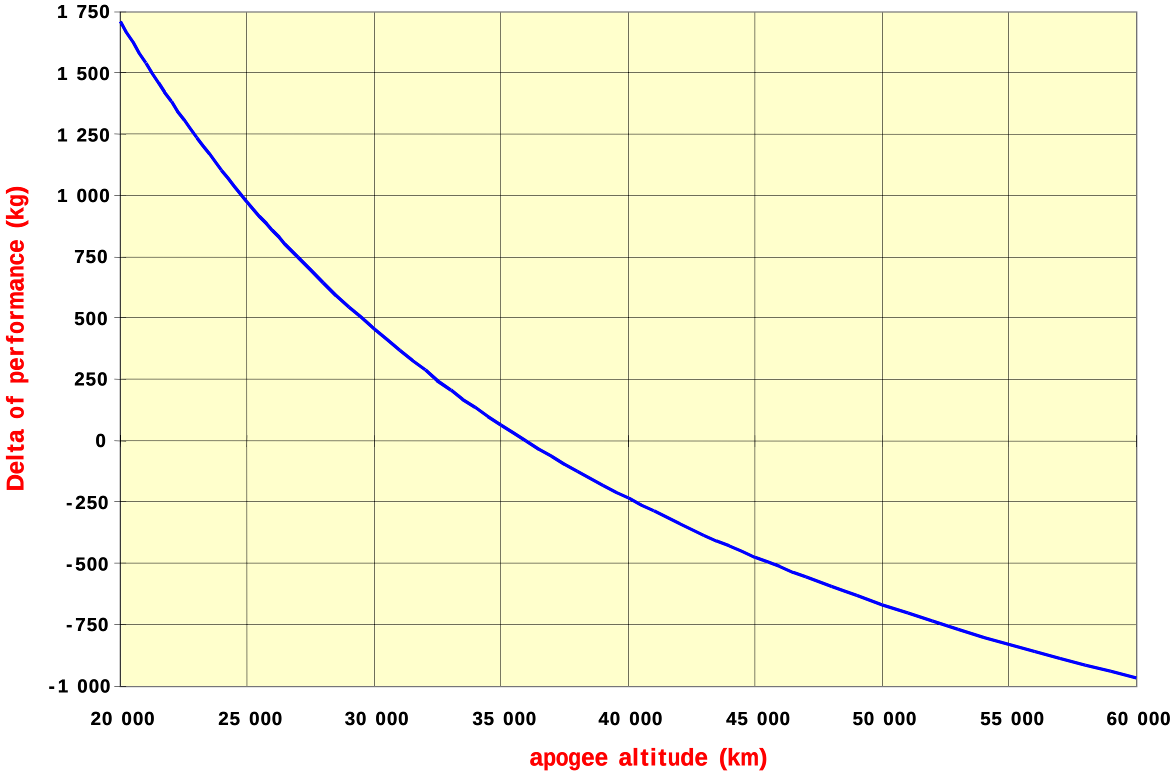


Figure 2.3.3.3.a - Performance Versus Variation of the Apogee Altitude

2.3.4. Sun Synchronous Orbit (SSO)

The launch vehicle performance is approximately **9.5 tons** on a 800 km circular orbit.

Performance computations are based on the following assumptions:

- Aerothermal flux at fairing jettison less than 500 W/m².
- Launch azimuth of 0° (due North).
- Inertial node control on a 10 min launch window.

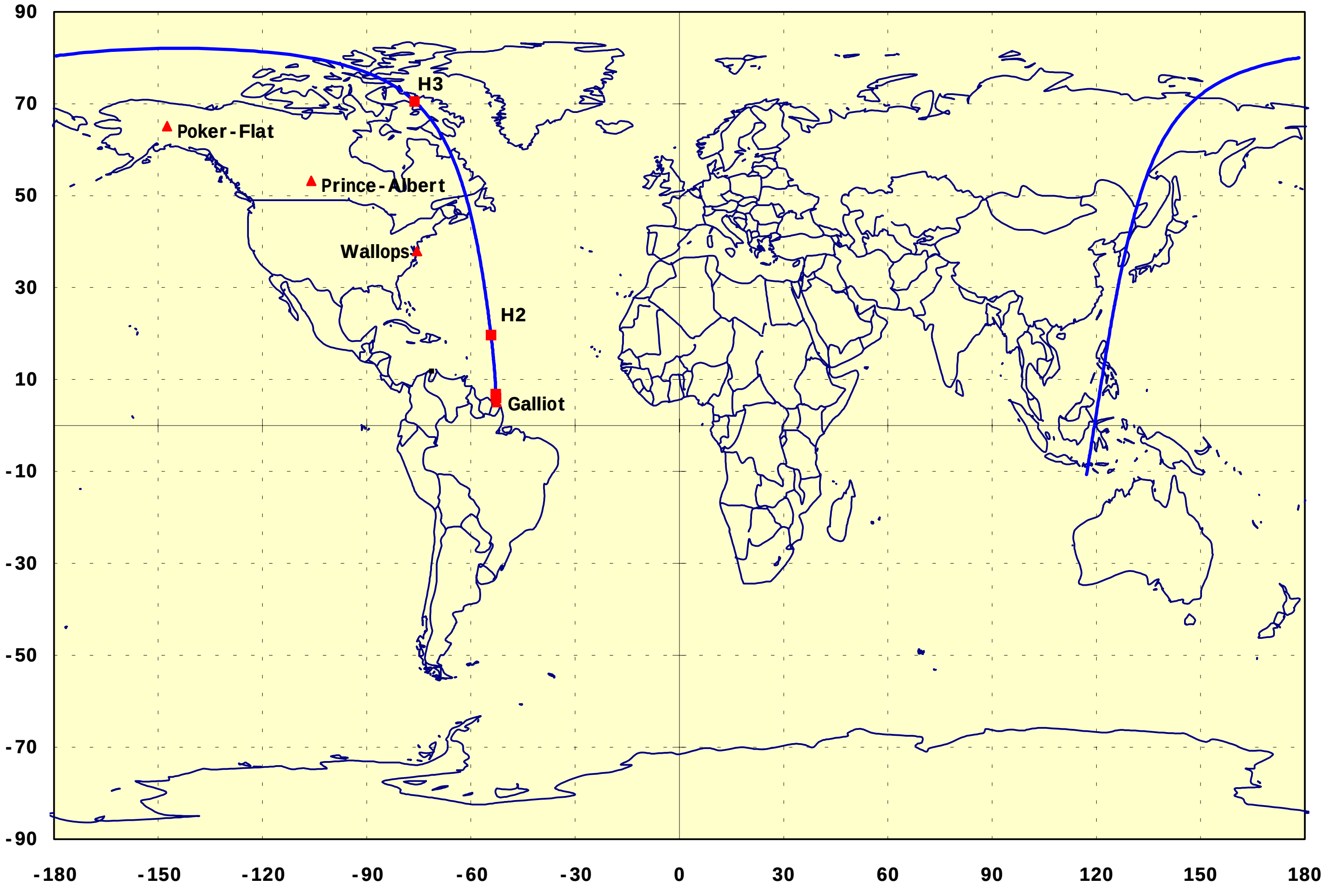


Figure 2.3.4.a – Sun Synchronous Injection Typical Ground Track

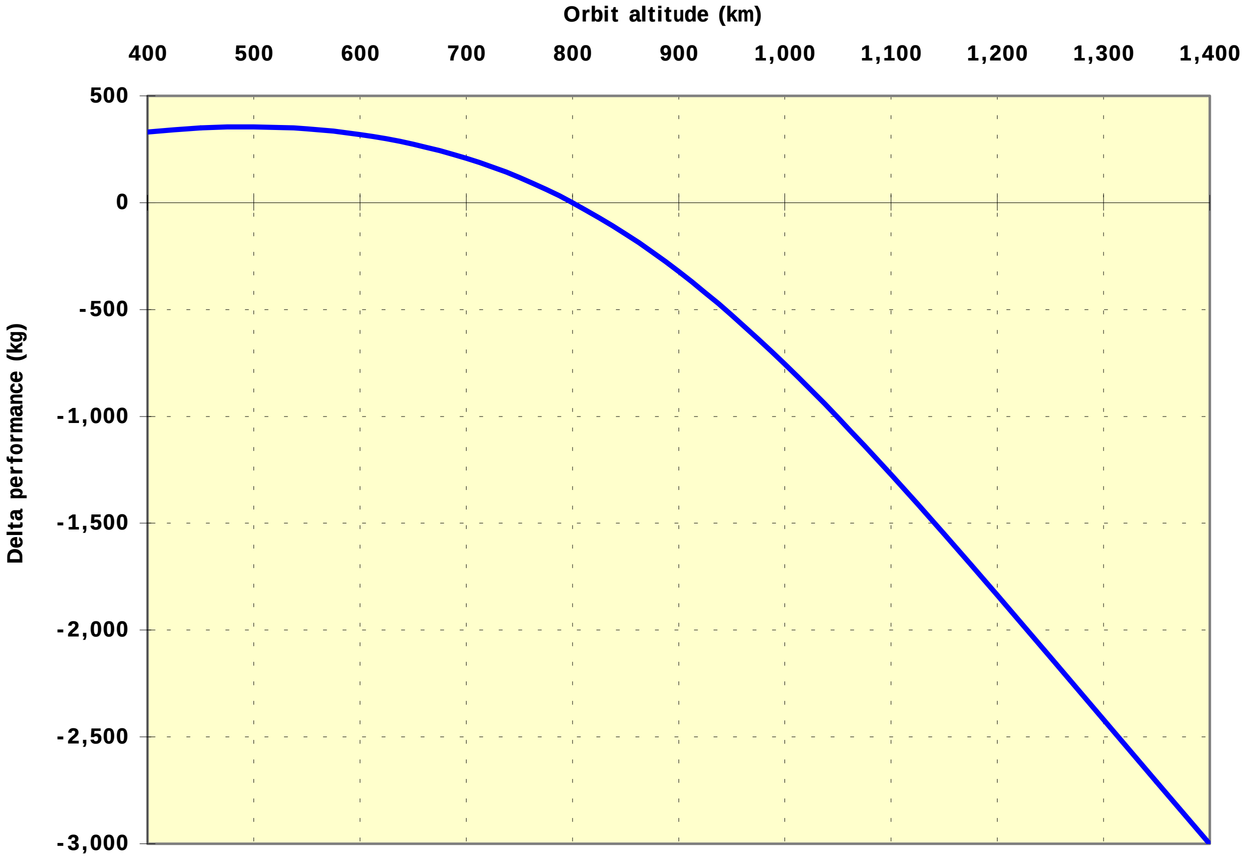


Figure 2.3.4.b – Performance Variation Versus Altitude

2.4. Ariane 5 ES

Except if otherwise specified the performance presented are those of the A 5 ES version.
When upper stage reignition is necessary to perform the mission, this capability is provided by implementing the necessary equipment on the upper stage and vehicle Equipment Bay.

Thanks to the upper stage reignition capability of the A5 ES upper stage, two different orbits can be reached during the same mission. For instance, for a multiple deployment, a first batch of spacecraft can be injected on an intermediate orbit, and then, after an upper stage second boost, a second batch can be inserted on the final orbit

2.4.1. Geosynchronous transfer performance

2.4.1.1. Ariane 5 ES standard Geostationary Transfer Orbit (GTO)

The standard Geostationary Transfer Orbit, is defined in terms of osculating parameters at injection remains:

- Inclination i = 7 deg
- Altitude of perigee Zp = 560 km
- Altitude of apogee Za = 35 890 km
- Argument of perigee ωp = 178 deg

Injection is defined as the end of upper stage thrust-decay.
Za is equivalent to true altitude 35 786 km at first apogee.
The longitude of the first descending node Ω, as defined in the figure 2.4.1.a usually lies around 14 deg West.

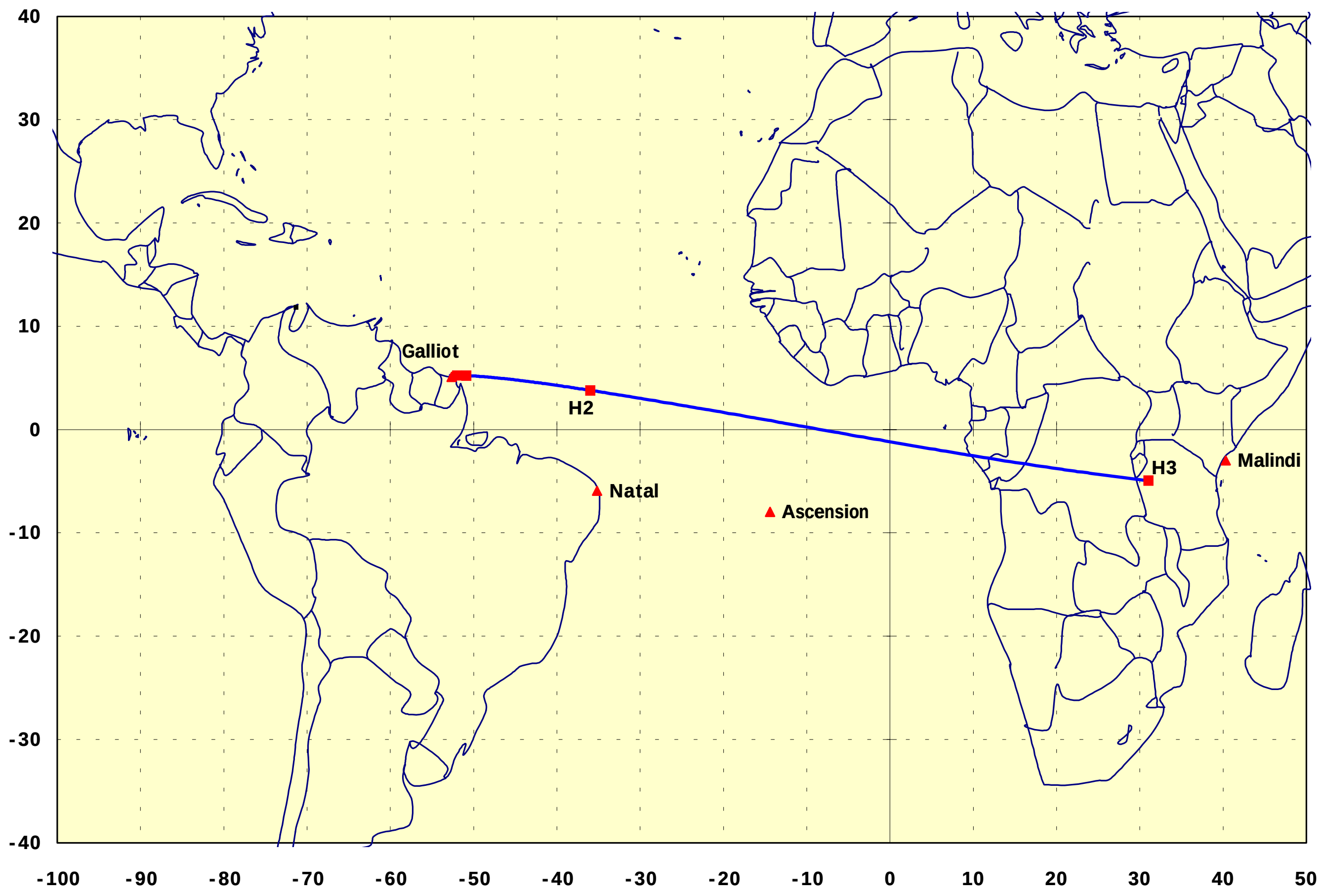


Figure 2.4.1.a – Typical Ground Track

2.4.1.2. Performance on the standard Geostationary Transfer Orbit

The ARIANE 5 ES performance is **7 575 kg**.

2.4.1.3. Injection Accuracy

Refer to paragraph 2.3.1.3.

2.4.1.4. Typical launch vehicle trajectory

Refer to paragraph 2.3.1.4.

2.4.2. Optimized geosynchronous transfer injection

Refer to paragraph 2.3.2.

2.4.3. Tailored GTO mission

Refer to paragraph 2.3.3.

2.4.4. Sun synchronous orbit

The performance is TBD.
Upper stage reignition allows to perform dual (or multiple) launches with slightly different orbits for the passengers. For more information on Ariane 5 capability to provide different inclination, altitude or local time please contact Arianespace.

2.4.5. Low Earth Orbits (LEO)

Among the wide range of orbits that can be served by ARIANE 5, some inclined circular orbits have been chosen to illustrate the ARIANE 5 performance. they ranged from 48 deg to 86 deg with altitude from 300 to 1 400 km.
For launches on such orbits users are invited to contact Arianespace.

Performance computations are based on the following assumptions:

- Aerothermal flux at fairing jettison less than 1135 W/m2.
- Inertial node control for a launch on time.
- Visibility constraints not taken into account (for performance impact please contact Arianespace).
- No spacecraft mission constraints.

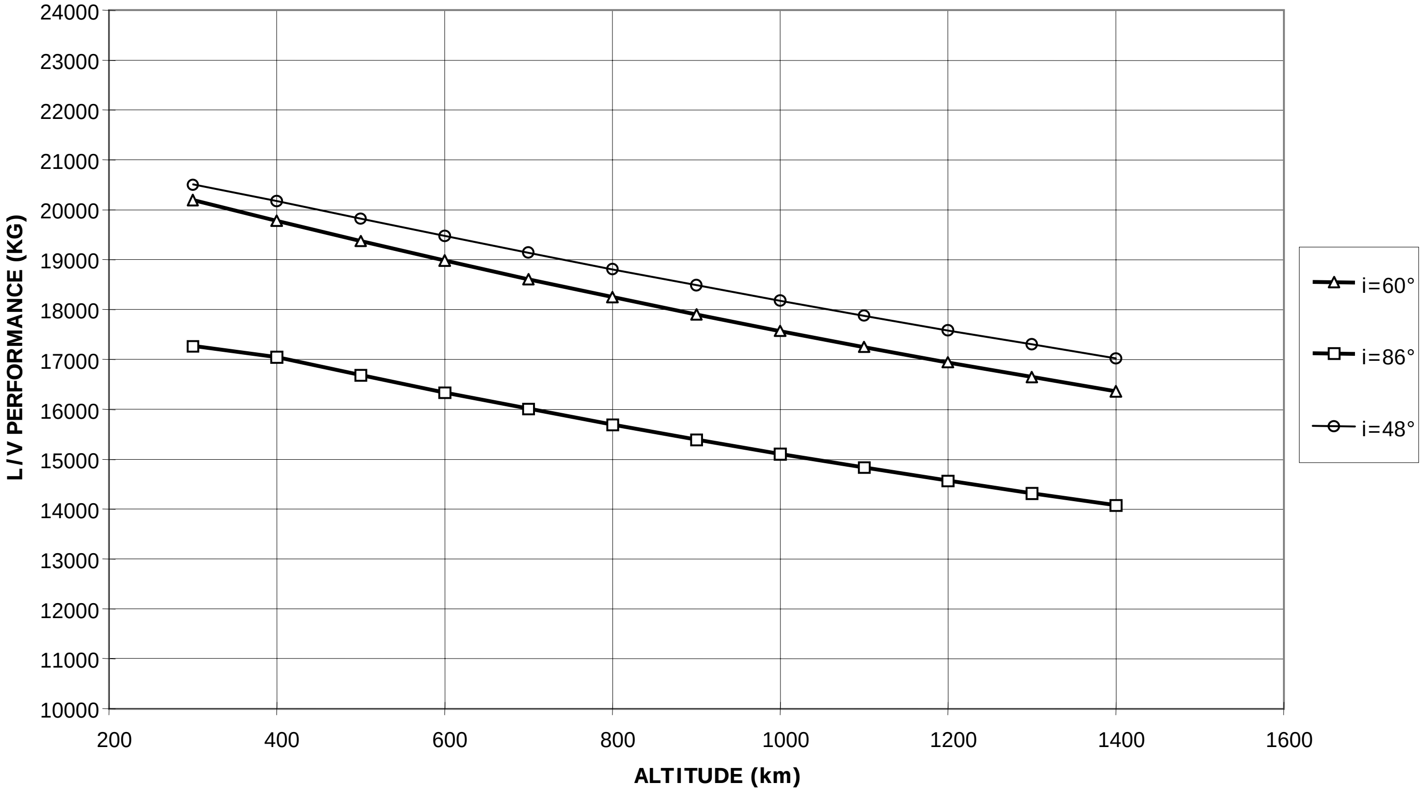


Figure 2.4.5.a. – Ariane 5 ES LEO Performance

2.4.6. High elliptical Orbits (HEO)

The 55° inclined orbit have been chosen to illustrate the ARIANE 5 ES performance. For such orbits, customers are invited to contact Arianespace to obtain precise data.

Performance computations are based on the following assumptions:

- Argument of perigee around 280 °.
- Ascending node free.
- Aerothermal flux at fairing jettisoning less than 1135 W/m².
- Visibility constraints not taken into account (for performance impact please contact Arianespace).
- No spacecraft mission constraints.

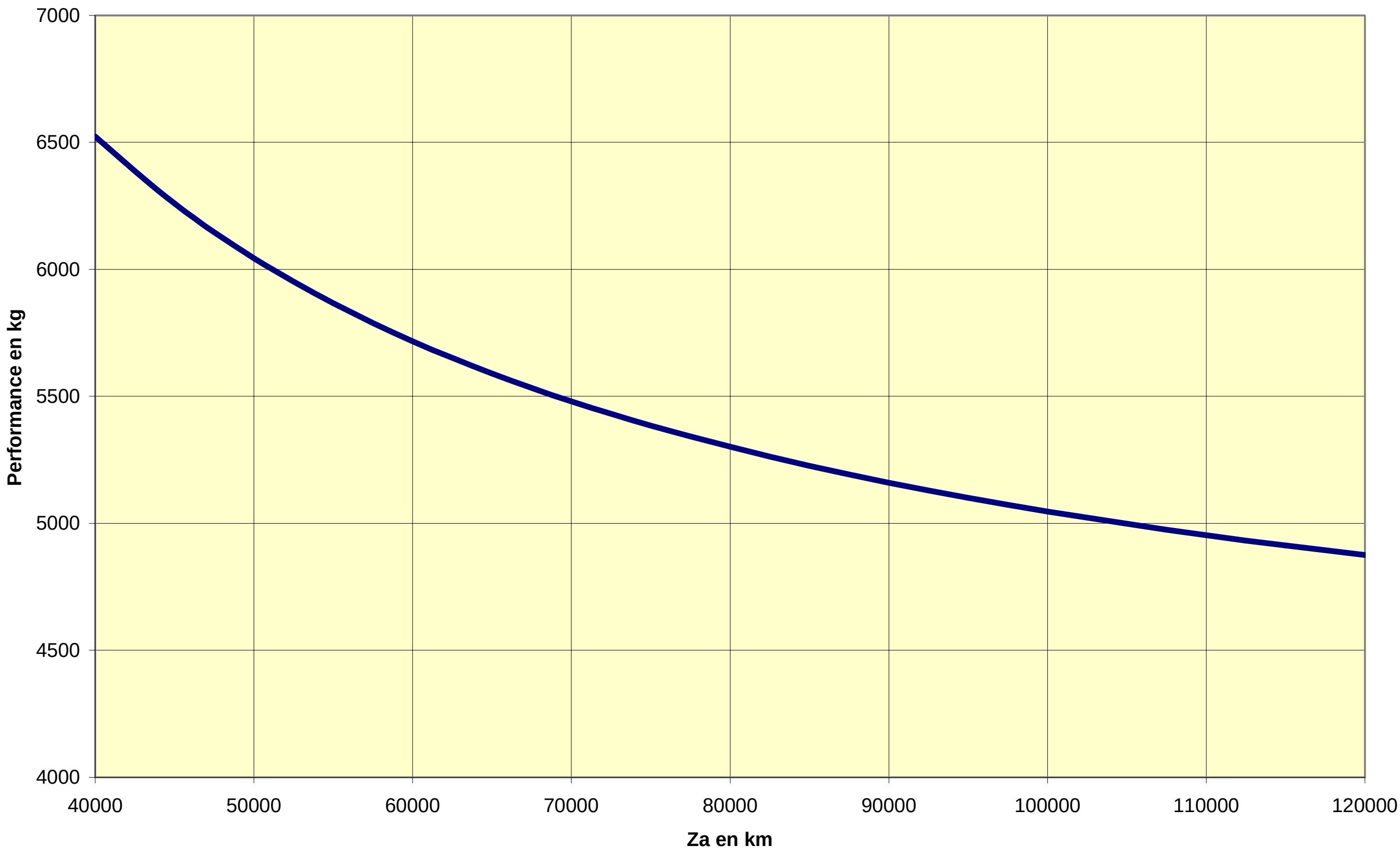


Figure 2.4.6.a – A5 ES Performance HEO: Zp = 200 km ; i = 55 deg ; w = 280 deg

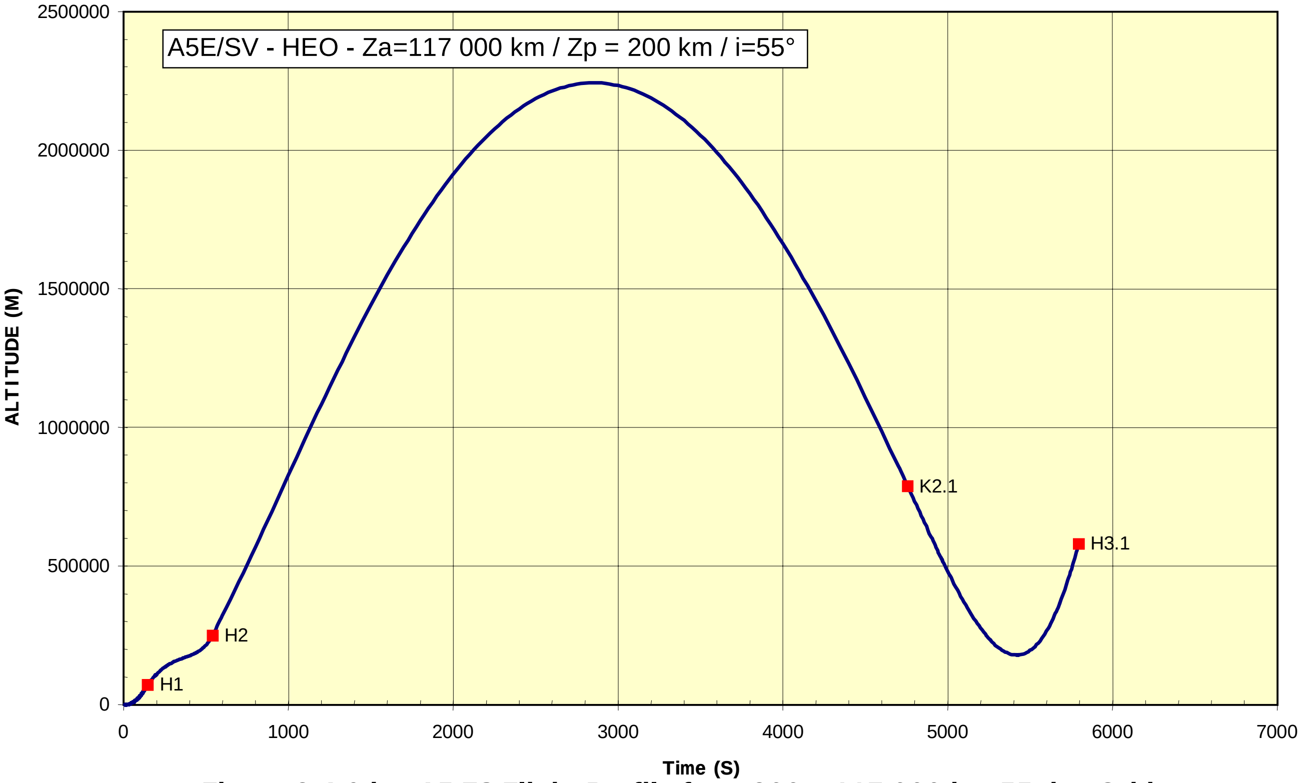


Figure 2.4.6.b – A5 ES Flight Profile for a 200 x 117 000 km 55 deg Orbit

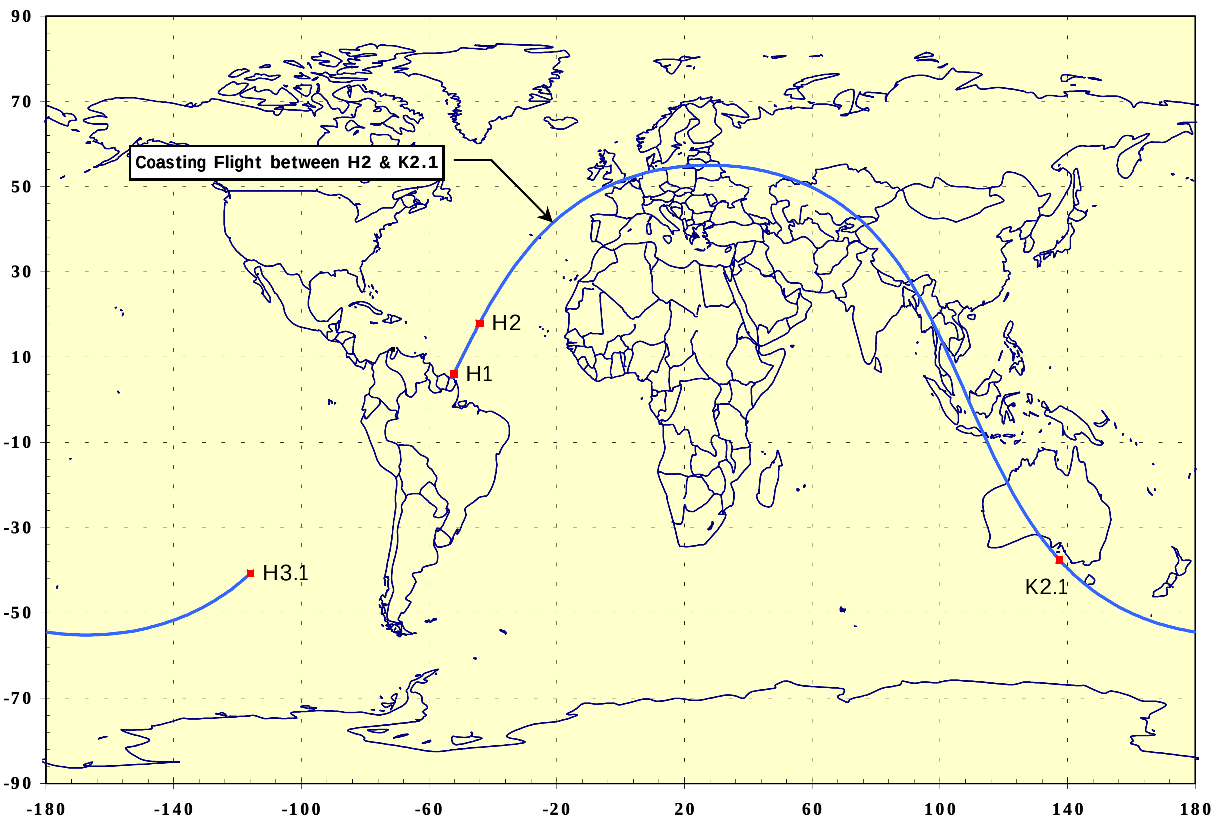


Figure 2.4.6.c - A5 ES Ground Track for a 200 x 117 000 km 55 deg Orbit

2.4.7. Medium Earth Orbit (MEO)

By inserting a coast phase between two upper stage burns A5 ES can ideally serve Medium Earth Orbits.
Typical performances are presented for two orbits:

- Circular i = 5 deg.
- Circular i = 55 deg

For such missions Customers are invited to contact Arianespace to obtain precise data.

Performance computations are based on the following assumptions:

- Aerothermal flux at fairing jettison less than 1135 W/m²
- Visibility constraints not taken into account (for performance impact please contact Arianespace).
- Ascending node free.
- No spacecraft mission constraints.

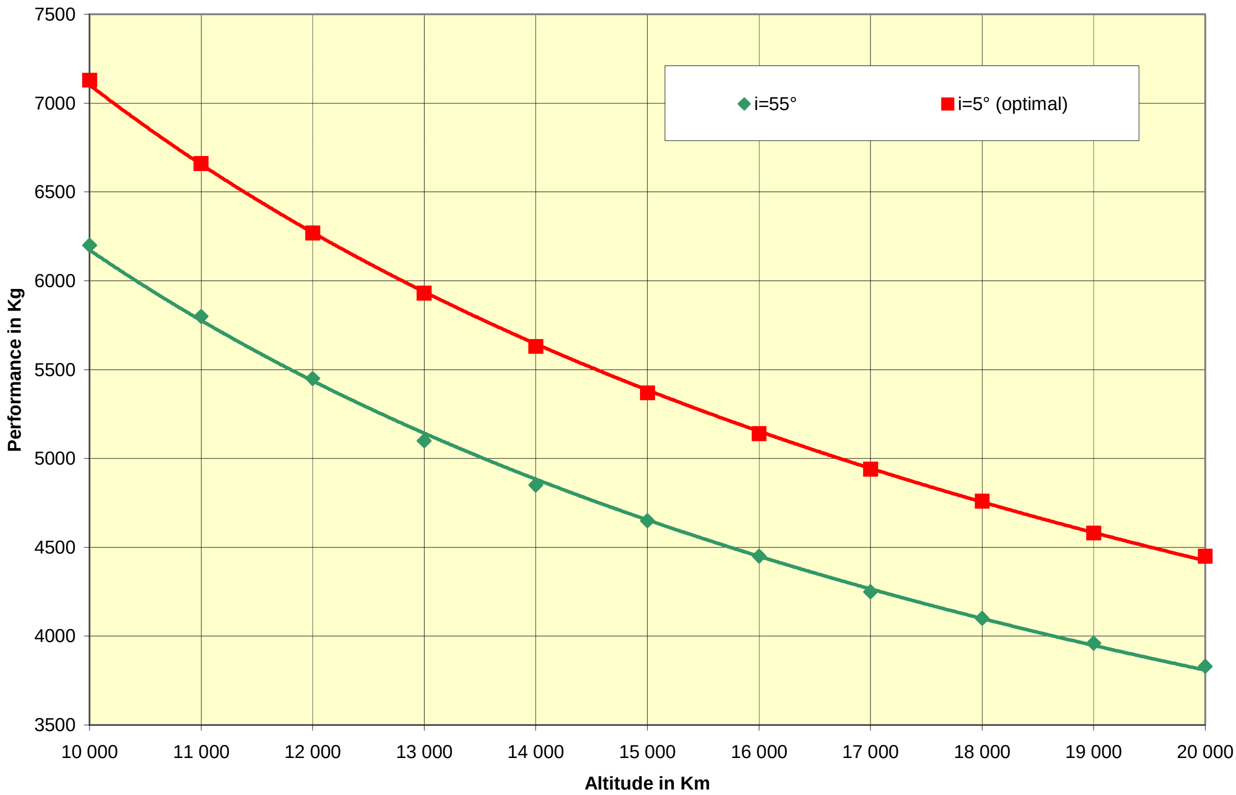


Figure 2.4.7.a – A5 ES Performance on Circular Orbits

2.4.8. Escape missions

In a near future, the ability to perform escape missions will be demonstrated through the launch of an exploratory probe.

The particularities of this mission are:

- Target orbit: V∞ 3 380 m/s
  Declination 1.99 deg
- Cost phase duration 7 000 s
- A5 ES performance: **3500 kg**

2.5. AR5 ECA

2.5.1. Ariane 5 ECA Standard Geostationary Transfer Orbit (GTO)

The Ariane 5 ECA standard Geostationary Transfer Orbit defined in terms of osculating parameters at injection is:

- Inclination i = 7 deg
- Altitude of perigee Zp = 250 km
- Altitude of apogee Za = 35 950 km
- Argument of perigee ωp = 178 deg

The longitude of the first descending node Ω, usually lies around 0 deg.
Injection is defined as the end of the upper stage thrust decay.

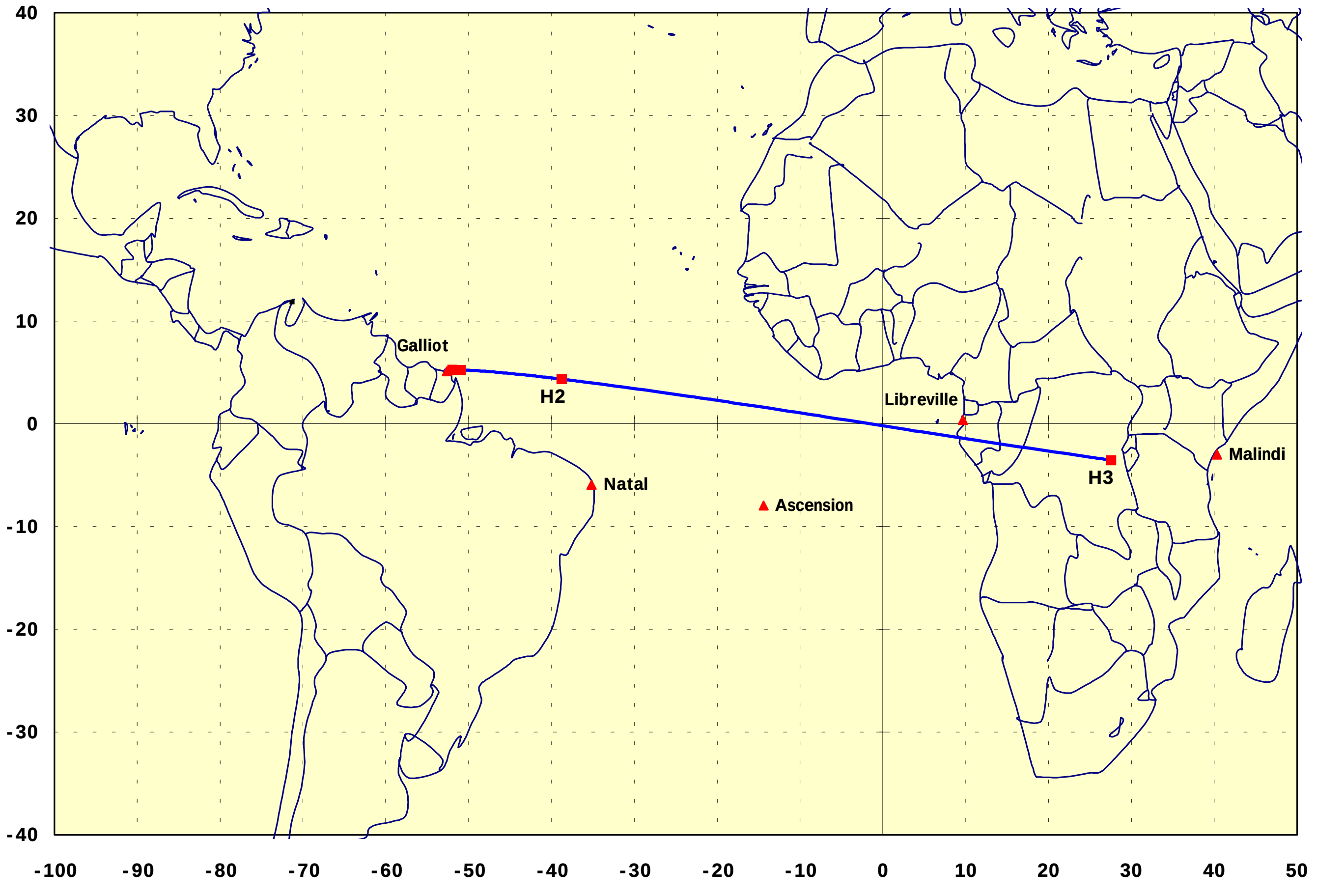


Figure 2.5.1.a – Ariane 5 ECA Typical Ground Track

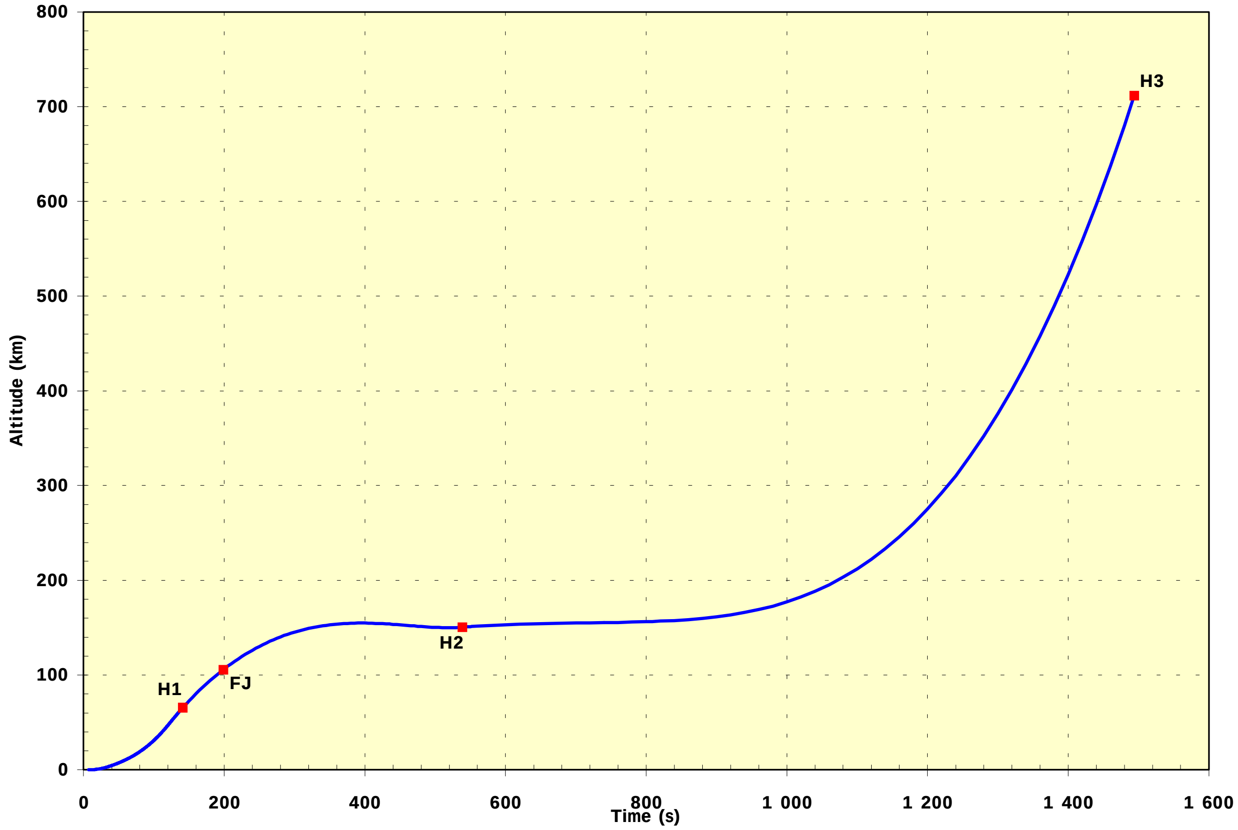


Figure 2.5.1.b – Ariane 5 ECA Trajectory – Altitude Versus Time

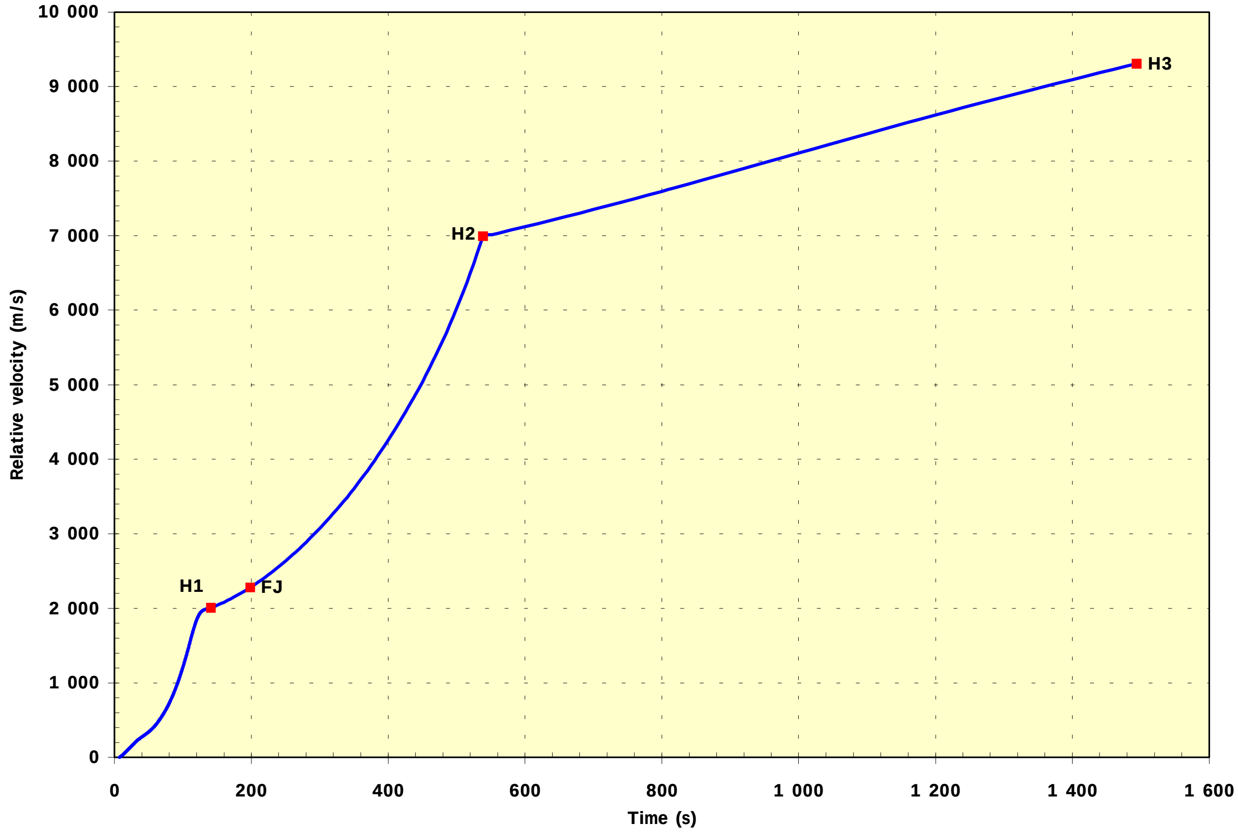


Figure 2.5.1.c – Ariane 5 ECA Trajectory – Relative Velocity Versus Time

2.5.1.1. Performance on the standard Geostationary Transfer Orbit

The ARIANE 5 ECA performance is **10 050 kg**.

2.5.1.2. Injection accuracy

The following table gives the typical standard deviation values (1 sigma):

a	semi major axis	40
e	excentricity	4.10^{-4}
i	inclination (deg)	0.02
ωp	argument of perigee (deg)	0.15
Ω	Ascending node (deg)	0.15

2.5.2. Tailored GTO mission

Although the ARIANE 5 standard Geostationary Transfer Orbit, with its low inclination, does already provide a good answer to achieve the lifetime requirement of the Customer, Arianespace can propose a wide range of options to further increase the spacecraft beginning of life propellant mass and Customer's revenue.

The ARIANE mission can be customized by some adjustments to the transfer orbit.

- Aerothermal flux can be set differently from 1135 W /m^2 standard. Increasing this value allow to increase the final launch vehicle performance.
- Inclination and Apogee altitude can be adapted, the associated performance impact is shown on figure 2.5.2.a and 2.5.2.b.

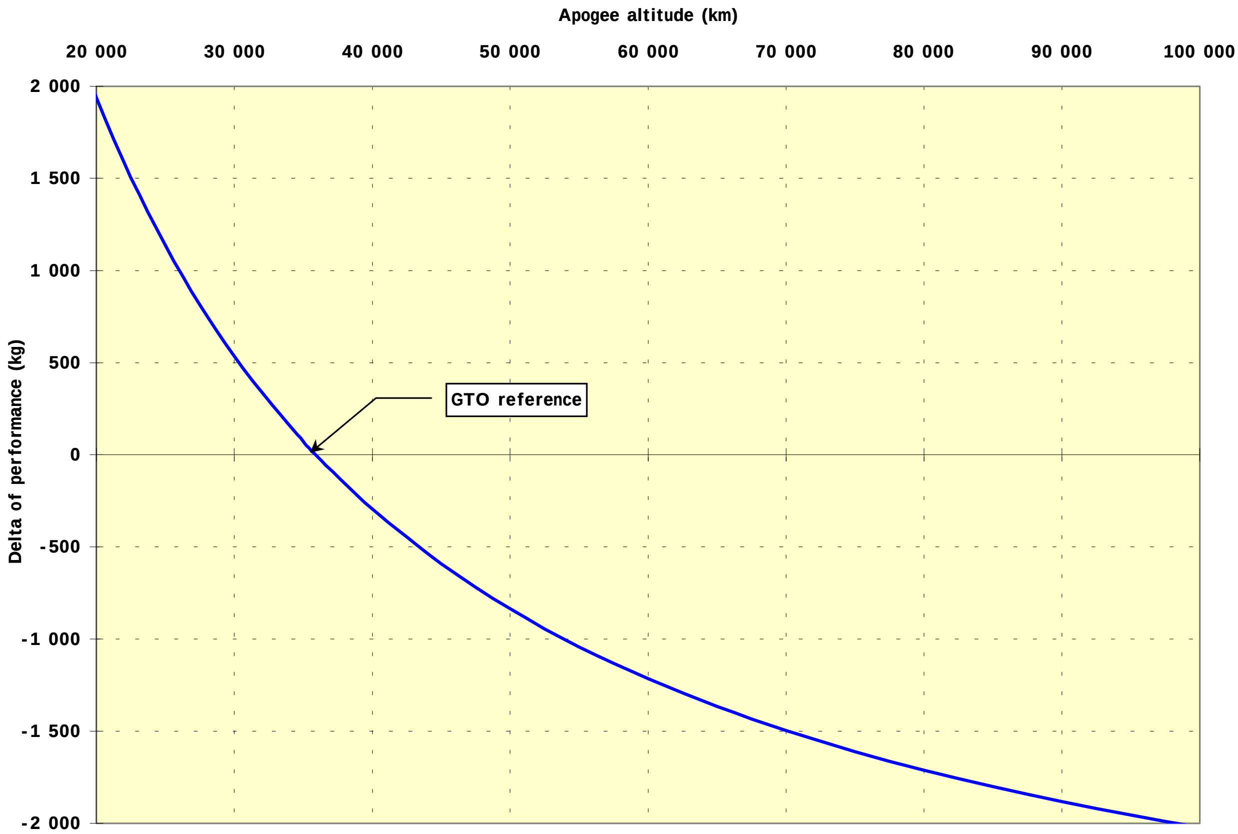


Figure 2.5.2.a - Delta Performance Versus of Apogee Altitude

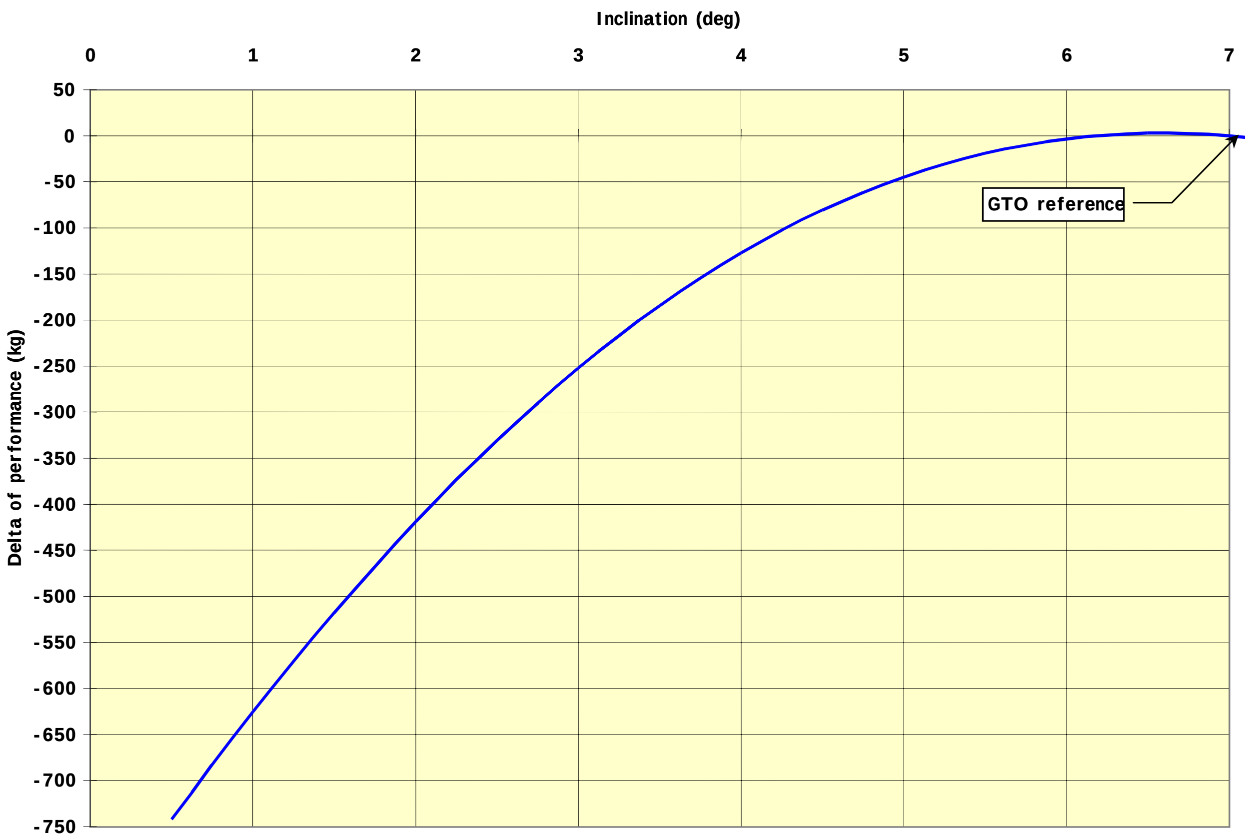


Figure 2.5.2.b – Delta Performance Versus of Inclination

2.5.3. Escape mission

As an example of escape mission, A5 ECA is intended to launch payload towards Mars. Such mission requires a C_3 = 18 km^2/s^2 and the performance is **5 200 kg**.

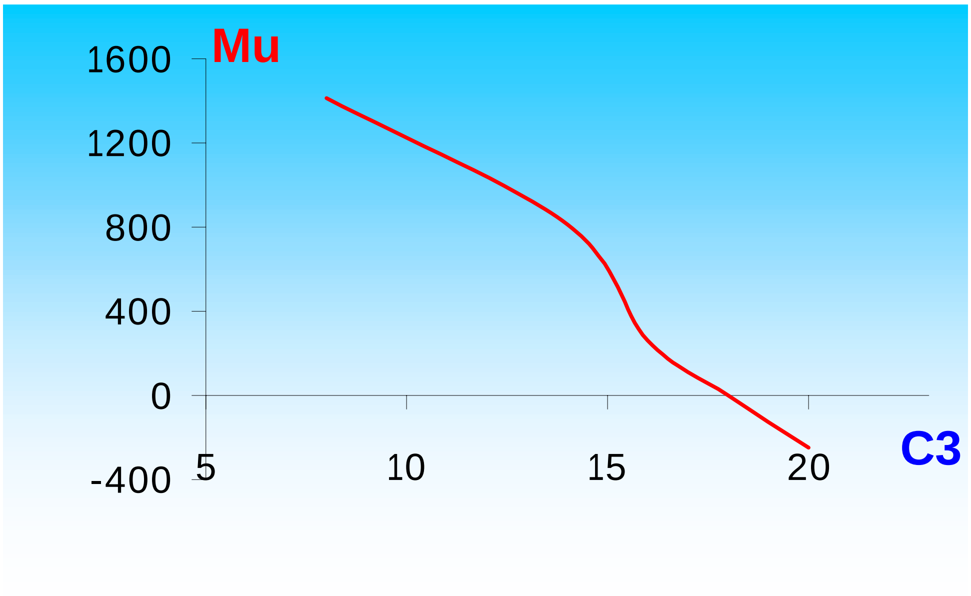


Figure 2.5.3.a – Evolution of the Performance as a Function of C_3

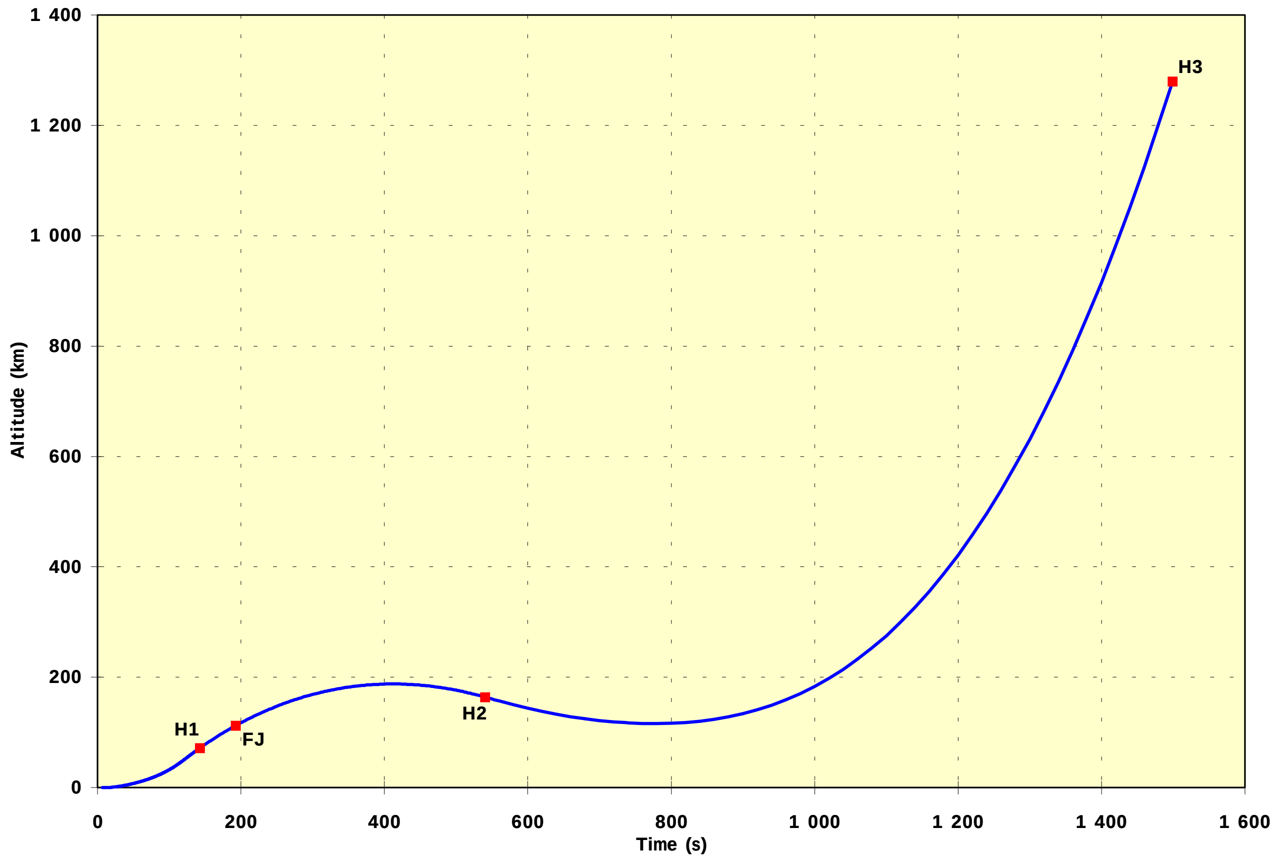


Figure 2.5.3.b – Mars Mission, Typical Flight Profile

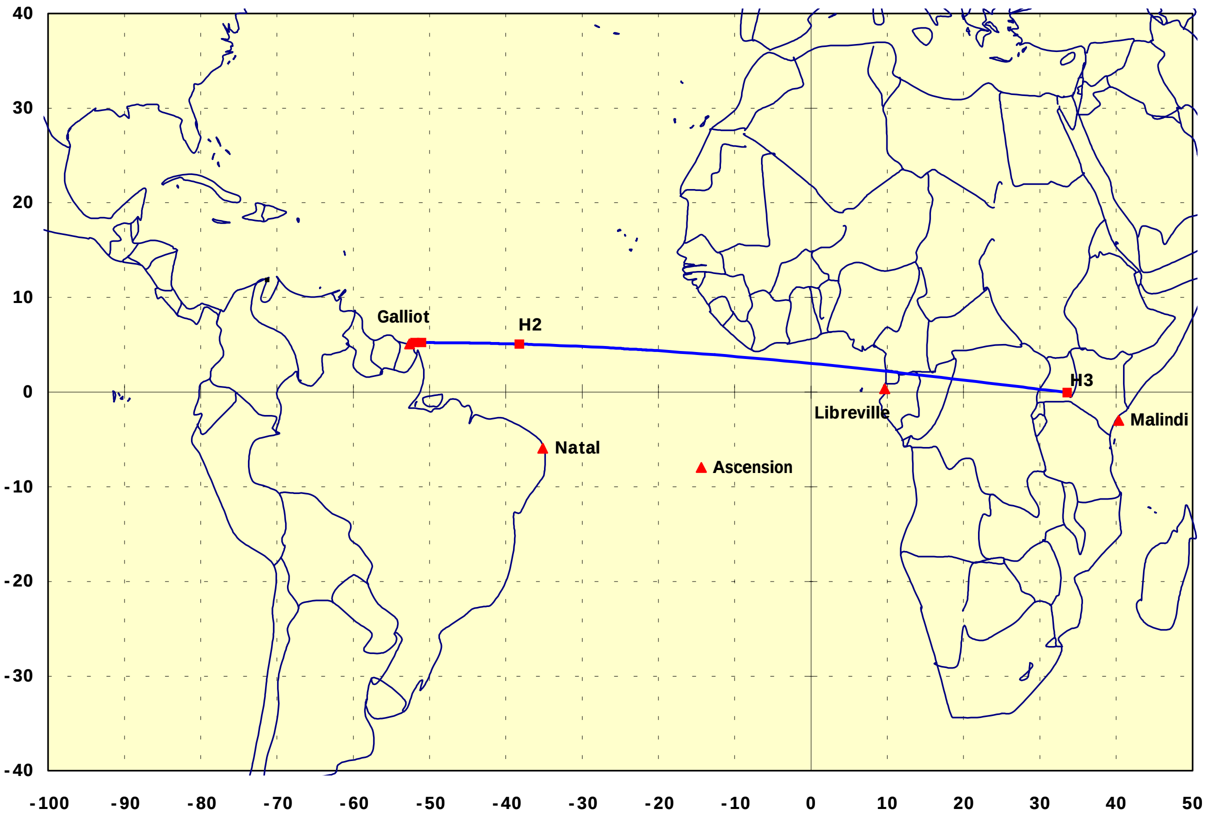


Figure 2.5.3.c – Mars Mission, Typical Ground Track

2.6. Spacecraft orientation and separation

2.6.1. General description

After injection into orbit, the launch vehicle Attitude Control System (SCA) is able to orient the upper composite to any desired attitude for each spacecraft and to perform separation(s) in various modes :
- 3-axis stabilization
- longitudinal spin
- transverse spin

After completion of the separation(s), the launch vehicle carries out a last manœuvre to avoid subsequent collision.
Typical sequences of events are shown in figures 2.6.1.a, 2.6.1.b (dual launch) and 2.6.1.c (single launch). Total durations of such sequences are respectively about 1100 s and 600 s (this duration is a Mission Analysis result for each specific mission).

2.6.2. Orientation performance

The attitude at separation can be specified by the Customer in any direction in terms of :
- fixed orientation during the entire launch window,
  or
- time variable orientation dependant on the sun position during the launch window.

Annex 3 (Documentation « D.U.A. », § 2.3) details the User specifications format required.
For other specific S/C pointing, the User should contact AE.

2.6.3. Separation mode and pointing accuracy

The actual pointing accuracy will result from the Mission Analysis (see para. 6.4).

The following values cover ARIANE 5 compatible spacecrafts as long as their balancing characteristics are in accordance with para. 4.5.3. They are given as S/C kinematic conditions immediately <u>after</u> separation and assume the adaptor and separation system are supplied by Arianespace.

In case the adaptor is provided by the Satellite Authority, the User should contact Arianespace for launcher kinematic conditions just <u>before</u> separation.

Possible perturbations induced by spacecraft sloshing masses are not considered in the following figures.

2.6.3.1. 3-Axis stabilized mode

In case <u>the maximum spacecraft static unbalance remains below **30 mm**</u> (for a 4500 kg maximum mass spacecraft - see para. 4.5.3.1. for heavier s/c), the following pointing accuracy is given with a 99% probability level:
- longitudinal geometrical axis depointing $\leq$ 1 deg,
- longitudinal angular tip-off rate $\leq$ 0.6 deg/s,
- transverse angular tip-off rate $\leq$ 1 deg/s.

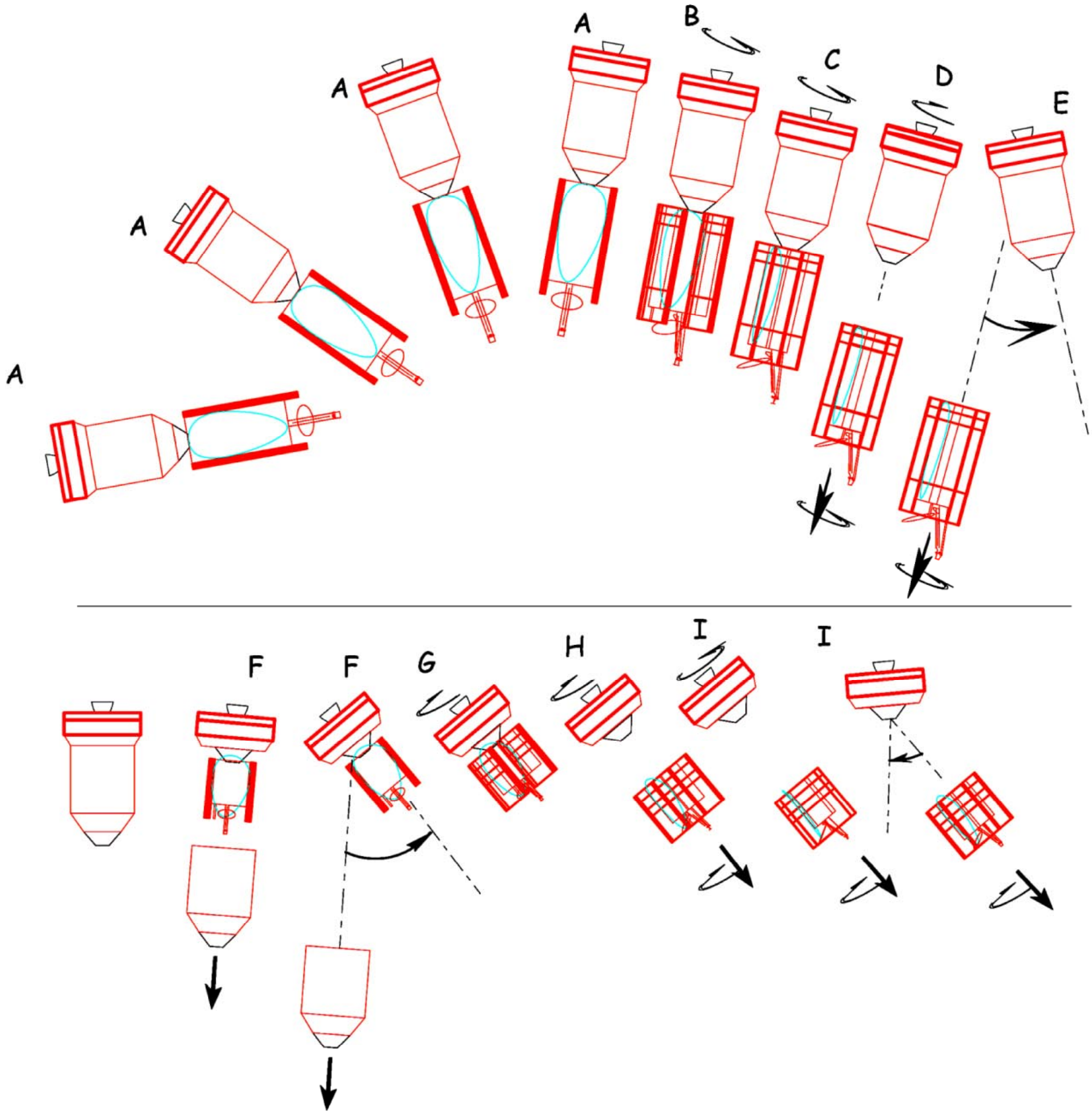
2.6.3.2. Spin stabilized mode

a/ Longitudinal spin
The Attitude Control System is able to provide a roll rate about the upper composite longitudinal axis up to 30 deg/s, clockwise or counter clockwise. The Preliminary Mission Analysis (see para. 6.4) may show that a higher spin rate could be provided, especially for a single launch.

b/ Transverse spin
A transverse spin can be provided by either asymmetrical separation pushrods (after a 3-axis stabilization of the launcher) or by the Attitude Control System through an upper composite tilting movement up to 3°/s according to spacecraft characteristics.

c/ <u>Example</u> (typical spin mode)
Although the spacecraft kinematic conditions just after separation are highly dependant on the actual spacecraft mass properties (including uncertainties) and the spin rate, the following values are typical results.

In case <u>the maximum spacecraft static unbalance remains below **30 mm** and its maximum dynamic unbalance remains below **1 deg**</u> (see para. 4.5.3.), the pointing accuracy for a longitudinal desired spin rate of 30 deg/s is given here after with a 99 % probability level:
- spin rate and accuracy = 30 $\pm$ 0.6 deg/s,
- transverse angular tip-off rate $\leq$ 2 deg/s,
- depointing of kinetic momentum vector $\leq$ 6 deg,
- nutation angle $\leq$ 5 deg.



A: Orientation of composite (Upper stage + VEB + payload) by attitude control system (SCA)

B and C: Spin-up by SCA

D: Separation of spacecraft

E: Spin-down and reorientation to SYLDA 5 jettisoning attitude

Note: Spacecraft separations can also be accomodated under a 3-axis stabilized mode.

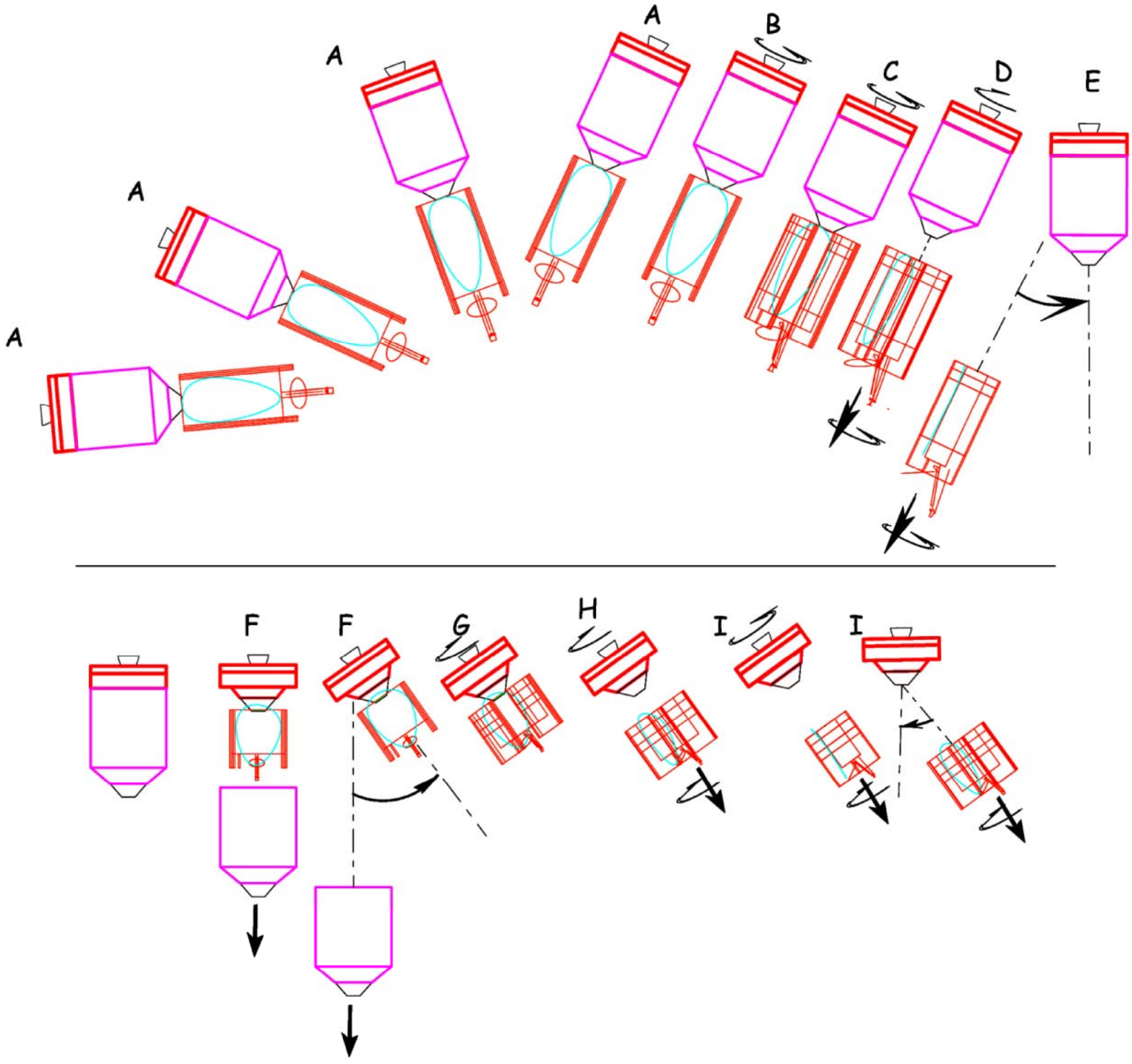
F: SYLDA 5 jettisoning.
Reorientation as requested by inner spacecraft.

G: Spin-up by SCA.

H: Separation of lower spacecraft.

I: Upper stage avoidance manœuvre (Spin down, attitude deviation by SCA and passivation).

Figure 2.6.1.a – Typical Spacecraft / SYLDA Separation Sequence for Various Attitude and Spin Requirements



A: Orientation of composite (Upper stage + VEB + payload) by attitude control system (SCA)

B and C: Spin-up by SCA

D: Separation of spacecraft

E: Spin-down and reorientation to SYLDA 5 jettisoning attitude

Note: Spacecraft separations can also be accomodated under a 3-axis stabilized mode.

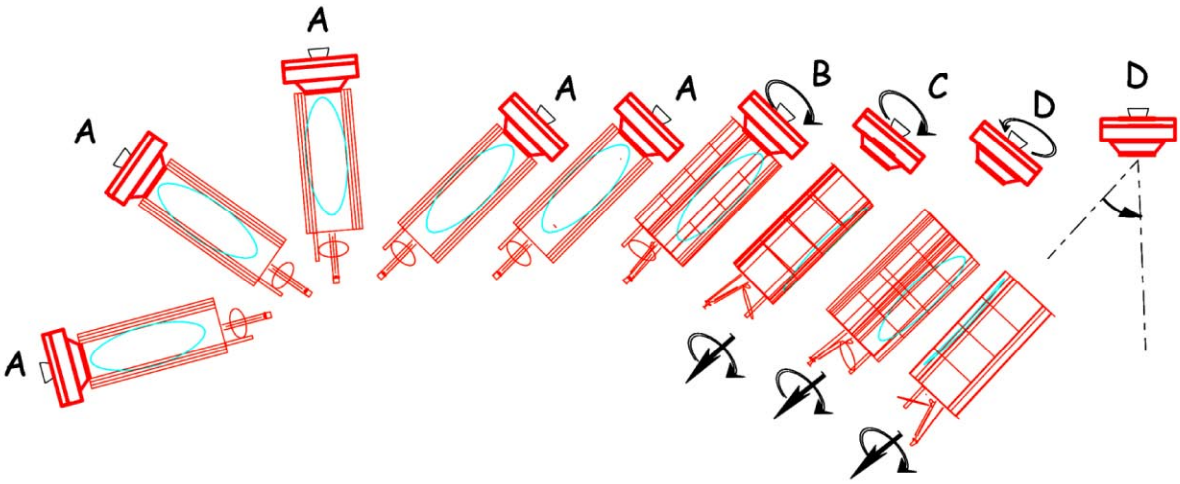
F: SPELTRA jettisoning. Reorientation as requested by inner spacecraft.

G: Spin-up by SCA.

H: Separation of lower spacecraft.

I: Upper stage avoidance manœuvre (Spin down, attitude deviation by SCA and passivation).

Figure 2.6.1.b – Typical Spacecraft / SPELTRA Separation Sequence for Various Attitude and Spin Requirements



A: Orientation of composite (Upper stage + VEB + payload) by attitude control system (SCA)

B: Spin-up by SCA

C: Separation of spacecraft

D: Upper stage avoidance manœuvre (Spin down, attitude deviation by SCA and passivation).

Note: Spacecraft separations can also be accomodated under a 3-axis stabilized mode.

Figure 2.6.1.c – Typical Spacecraft Separation Sequence (Single Launch)

2.6.4. Separation linear velocities and collision risk avoidance

Each separation system is designed to deliver a minimum relative velocity of 0.5 m/s between the two separated bodies.

For each mission, Arianespace will verify that the distances between orbiting bodies are adequate to avoid any risk of collision.
For this analysis, the User has to provide Arianespace with its orbit and attitude manœuvre flight plan, otherwise the s/c is assumed to have a pure ballistic trajectory (i.e. no s/c manœuvre occurs after separation).

2.6.5. Multi-separation capabilities

ARIANE is also able to perform multiple separations with a payload dispenser (DCU) as shown in annex 12.

For more information, please contact Arianespace.

Environmental conditions

Chapter 3

3.1. Mechanical environment

3.1.1. General

During flight, the payload is subjected to static and dynamic loads induced by the launch vehicle. This environment covers the ground transportation in Guiana.

Such excitation may be of aerodynamic origin (wind, gusts, buffeting at transonic velocity), or due to the propulsion systems (longitudinal acceleration, thrust build-up or tail-off transients, structure-propulsion coupling, attitude control limit cycling, etc).

The loads quoted in para. 3.1.2. to 3.1.7. should be considered as flight loads, applying to the spacecraft. The related probability of these figures not being exceeded is 99 %.

In the following paragraphs, the spacecraft base is defined as the top of the adaptor used.

3.1.2. Steady state acceleration

The highest longitudinal acceleration occurs at the end of the P230 boost phase. It will not exceed 4.55 g (see fig. 3.2.1.a).

Highest lateral acceleration is 0.25 g.

3.1.3. Low frequency longitudinal vibration

The sinusoïdal vibration level at the base of the spacecraft is ≤ 1 g in the fequency range from 5 to 100 Hz.

This spectrum takes into account all sinusoïdal or transient vibrations in this bandwidth.

3.1.4. Low frequency lateral vibration

The sinusoïdal vibration level at the base of the spacecraft is ≤ 0.8 g from 2 to 25 Hz and ≤ 0.6 g from 25 to 100 Hz.

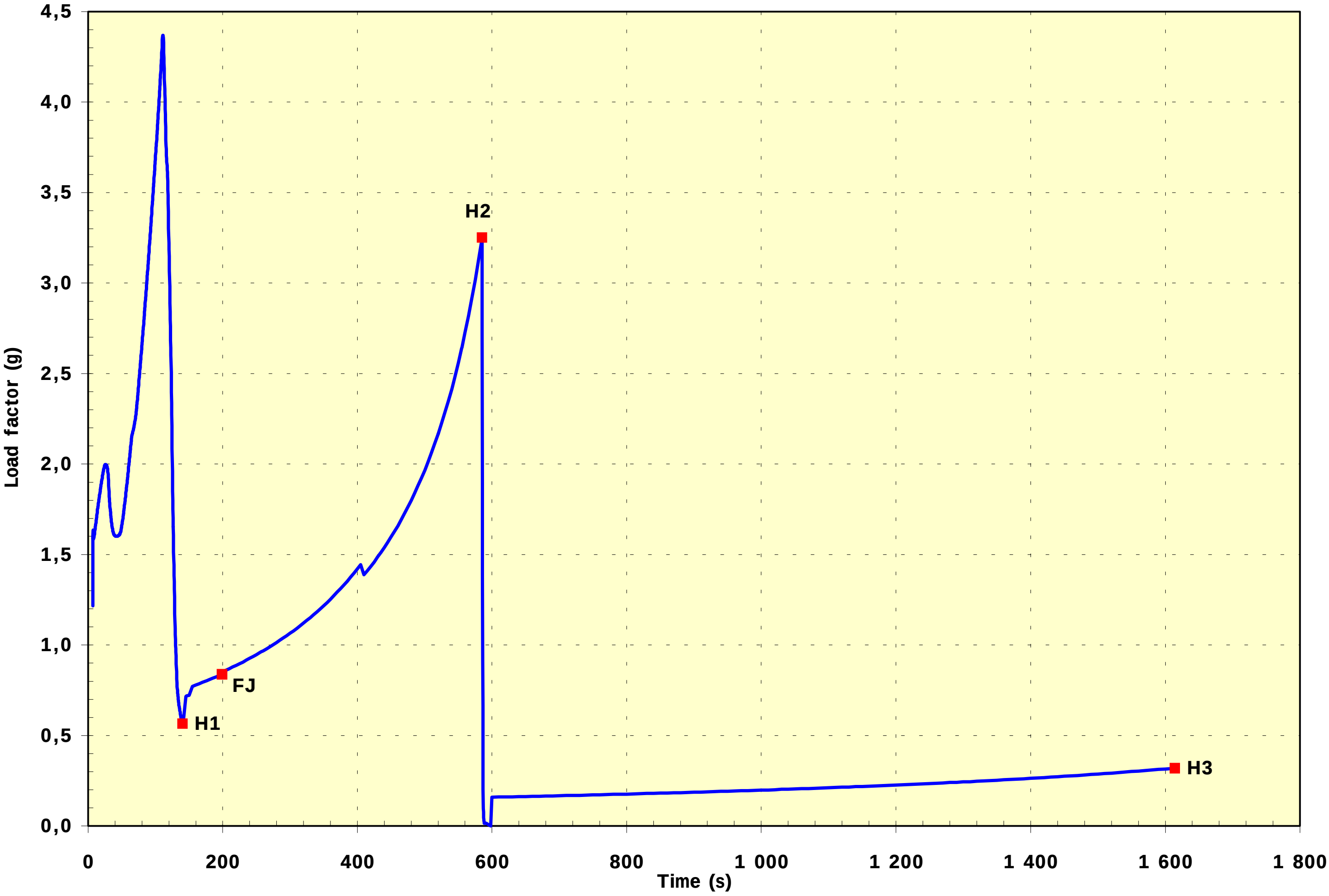


Figure 3.1.2.a - Typical Longitudinal Static Accelerations

3.1.5. Acoustic vibrations

Random vibrations are generated by engine noise, buffeting and boundary layer noise.

The highest level is at lift-off and in the transonic region. It is substantially lower outside these periods. (The related noise spectrum is shown in figure 3.1.5.a).

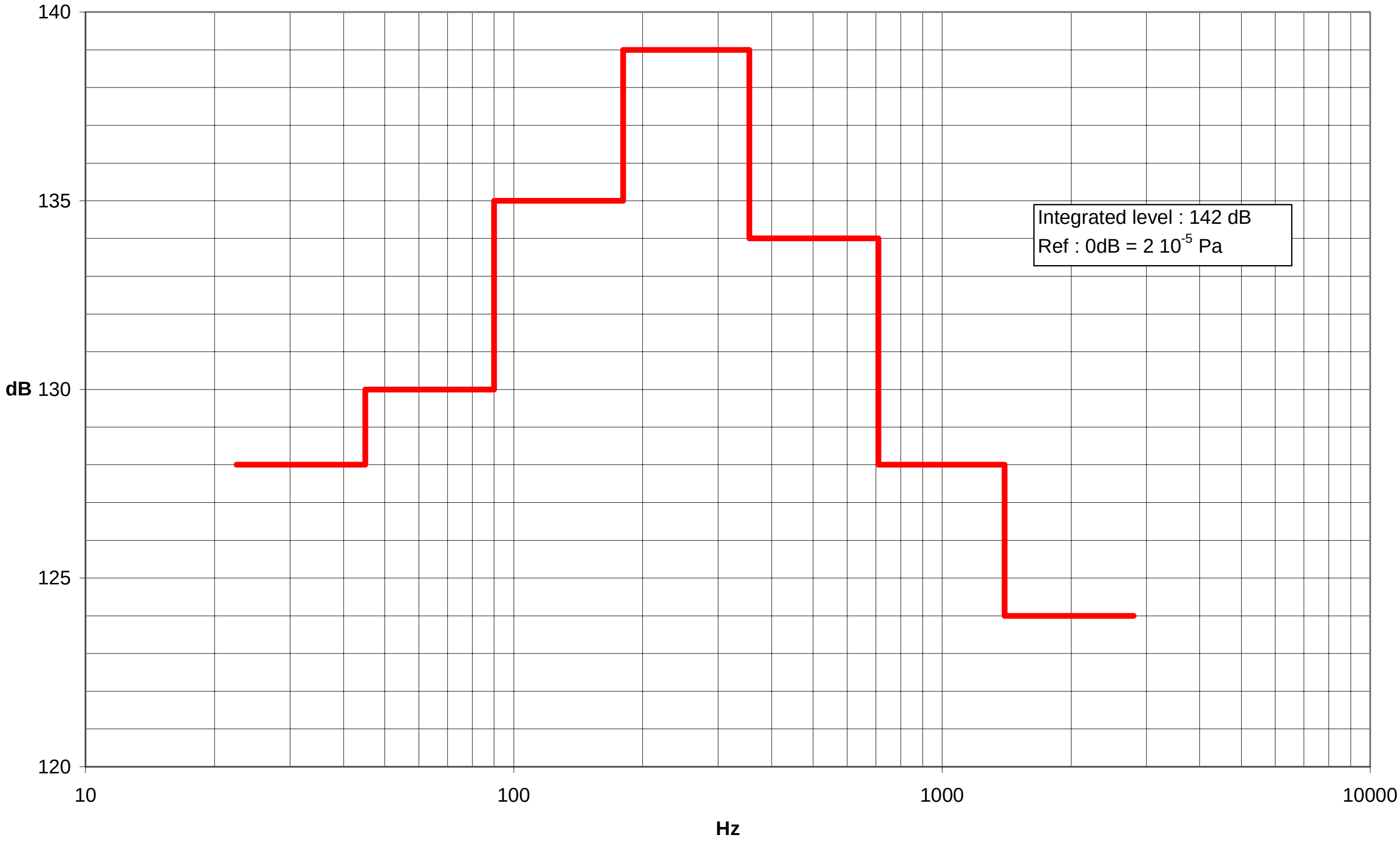


Figure 3.1.5.a – Acoustic Vibrations

3.1.6. Shock

The spacecraft is subjected to shocks mainly during separation of the fairing and on actual spacecraft separation. On Ariane 5, the fairing and the cryogenic stage / upper stage separation shocks are noticeable at the spacecraft interface. The envelope of actual spacecraft separation environment and shocks generated during the flight presented in figure 3.1.6.a has to be considered.

The level generated by the spacecraft separation system only, are represented in the annexes describing the various adaptors.

3.1.6.1. Client adaptor

The acceptable levels at the launch vehicle interfaces are shown in figure 3.1.6.b.

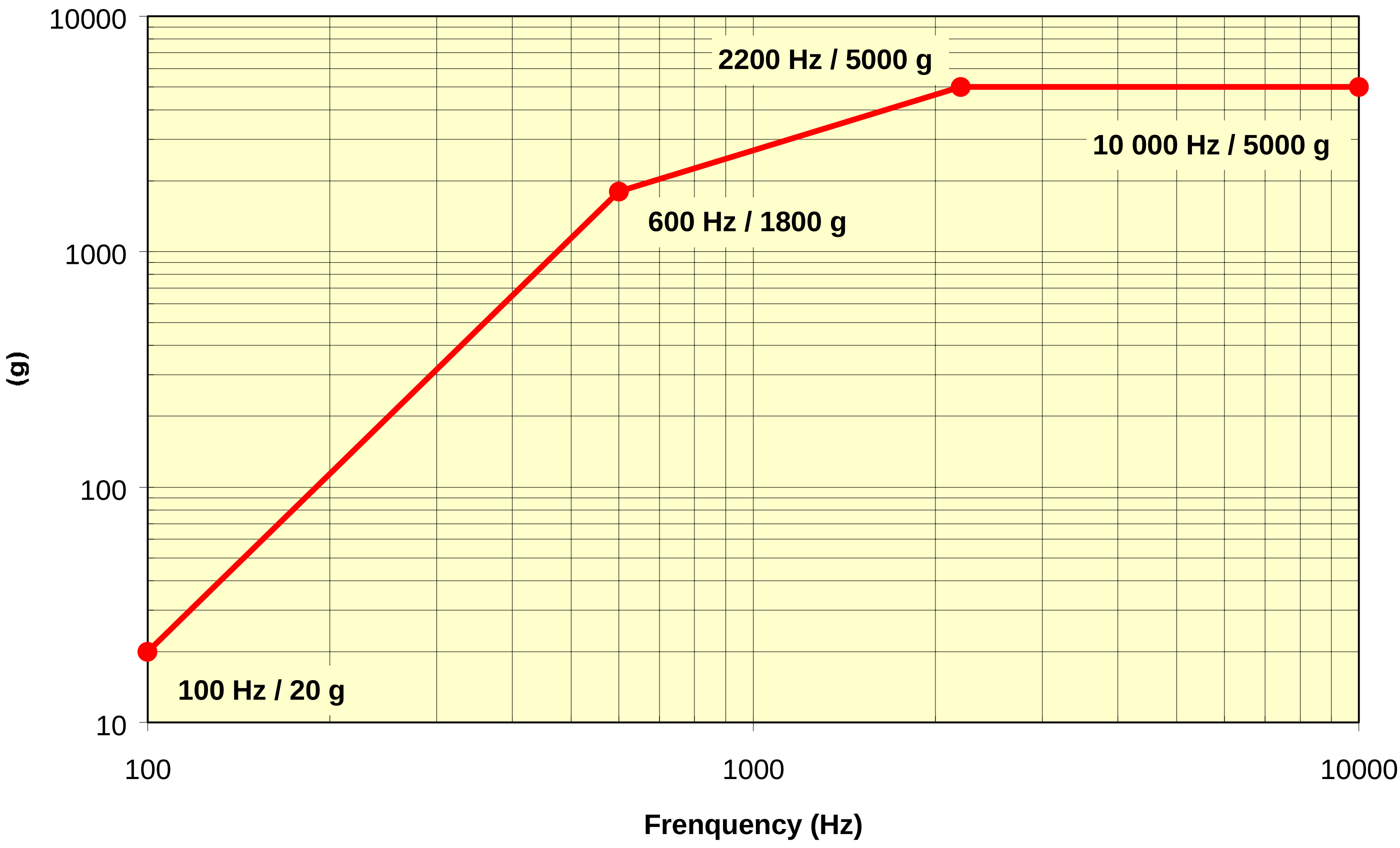


Figure 3.1.6.a – Envelope Shock Spectrum at Spacecraft Separation Interface

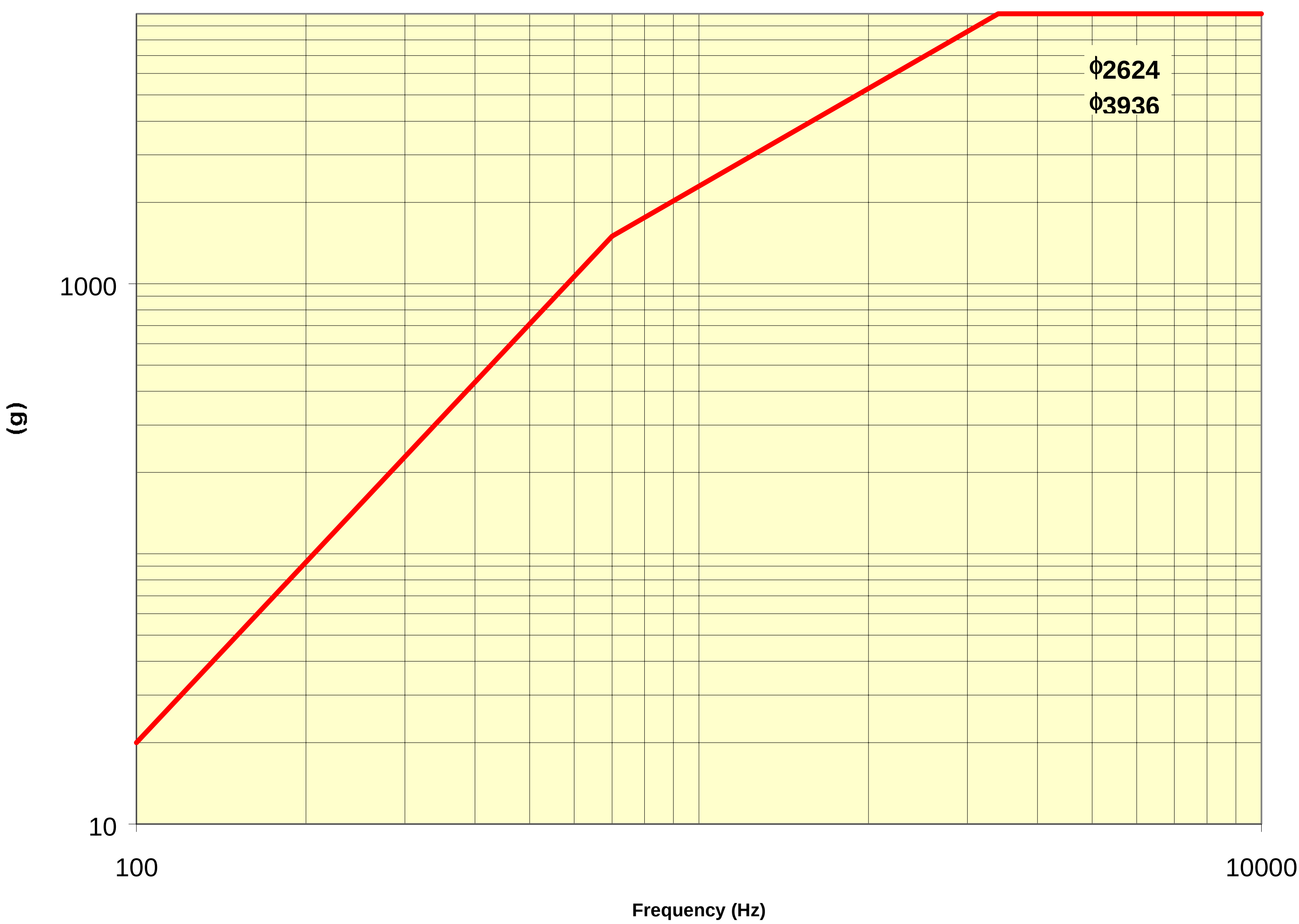


Figure 3.1.6.b – Acceptable Shock Spectrum at Launcher Bolted Interfaces

3.2. Thermal environment

3.2.1. General

Three phases have to be considered:

a) The spacecraft preparation phase within the EPCU buildings and transport between these buildings (refer to the EPCU Manual).

b) The spacecraft encapsulated inside the fairing, the SPELDA or SYLDA 5, and mated to the launch vehicle within the Final Assembly Building (BAF).

c) The transfer to the launch pad and the final pre-launch phase.

3.2.2. Pre-launch temperature within the fairing, SPELTRA or SYLDA 5

During the encapsulation phase and once mated to the launch vehicle, the spacecraft is protected by an air-conditioning system provided by ventilation through the pneumatic umbilicals (see fig. 3.2.2.a).

This system is compatible with class 100,000 cleanliness and has the following characteristics:

- Inlet temperature of injected air: adjustable between 10 °C and 25°C in the BAF, on the launch pad (ZL) and for the transfer phase to the launch pad.
- Outlet temperature of air (fairing or SPELTRA or SYLDA 5 venting holes) ≤ 25°C.
- Relative humidity ≤ 55 %.
- Filtration: 0.3 µm.
- Main air velocity within the fairing SPELTRA or SYLDA 5: < 2 m/s (locally, the velocity may exceed this value — contact ARIANESPACE in case of specific concern).
- The noise level generated by the ventilation system does not exceed 94 dB.

The maximum dissipated power considered for each spacecraft and for various phases is:
- During preparation in BAF: 1000 W.
- During transfert phase from BAF to launch pad: 200 W.
- On the launch pad (including hold and aborted launch): 700 W (up to 1000 W during 2 hours).
- In flight: 700 W.

3.2.3. In-flight temperature under fairing, SPELTRA or SYLDA 5

The net flux density radiated by the fairing, and the SPELTRA or the SYLDA 5 does not exceed 1000 W/m^2 at any point.
This figure does not take into account any effect induced by the spacecraft dissipated power.

3.2.4. Aerothermal flux at fairing jettisoning

(Not applicable to the inner passenger of a dual flight which remains protected by the SPELTRA or the SYLDA 5).

The nominal time for jettisoning the fairing on all flights is determined in order not to exceed the aerothermal flux of 1135 W/m^2. This flux is calculated as a free molecular flow acting on a plane surface perpendicular to the velocity direction (atmosphere US 66, latitude 15° North).

For the standard GTO mission, the typical free molecular heating profile is presented in figure 3.2.4.a. for A5G and A5ES and on 3.2.4.b. for A5ECA.

For dedicated launches (or multiple launch if agreed by passengers), lower or higher flux exposures can be accomodated on request. The performance impact is presented on chapter 2.

Solar-radiation flux, albedo and terrestrial infrared must be added to this aerothermal flux. In calculating the incident flux on spacecraft, account must be taken of the altitude of the launch vehicle, its orientation, the position of the sun with respect to the launch vehicle, and the orientation of the spacecraft surfaces considered.

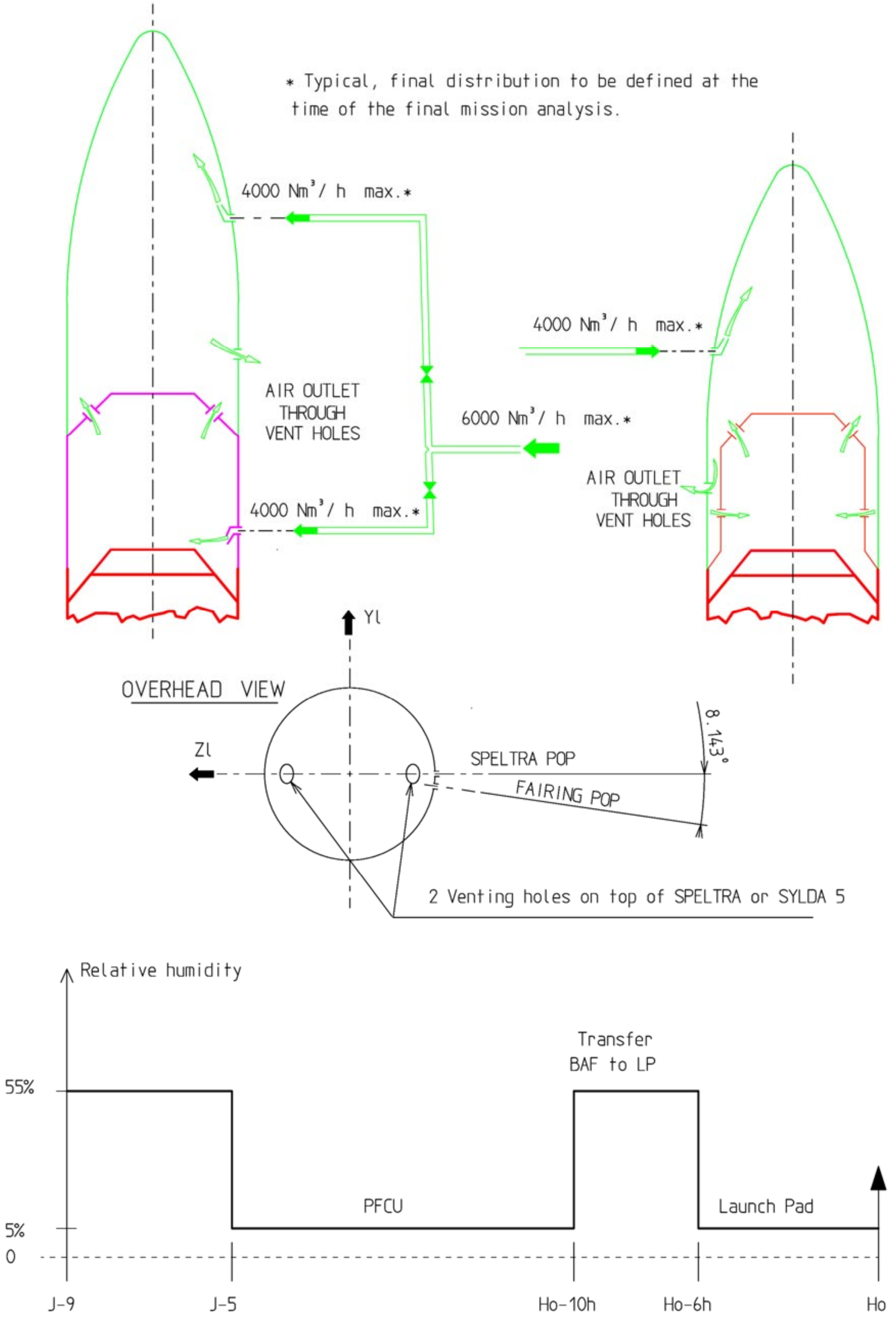


Figure 3.2.2.a – Shematic of Ventilation within Payload Volume

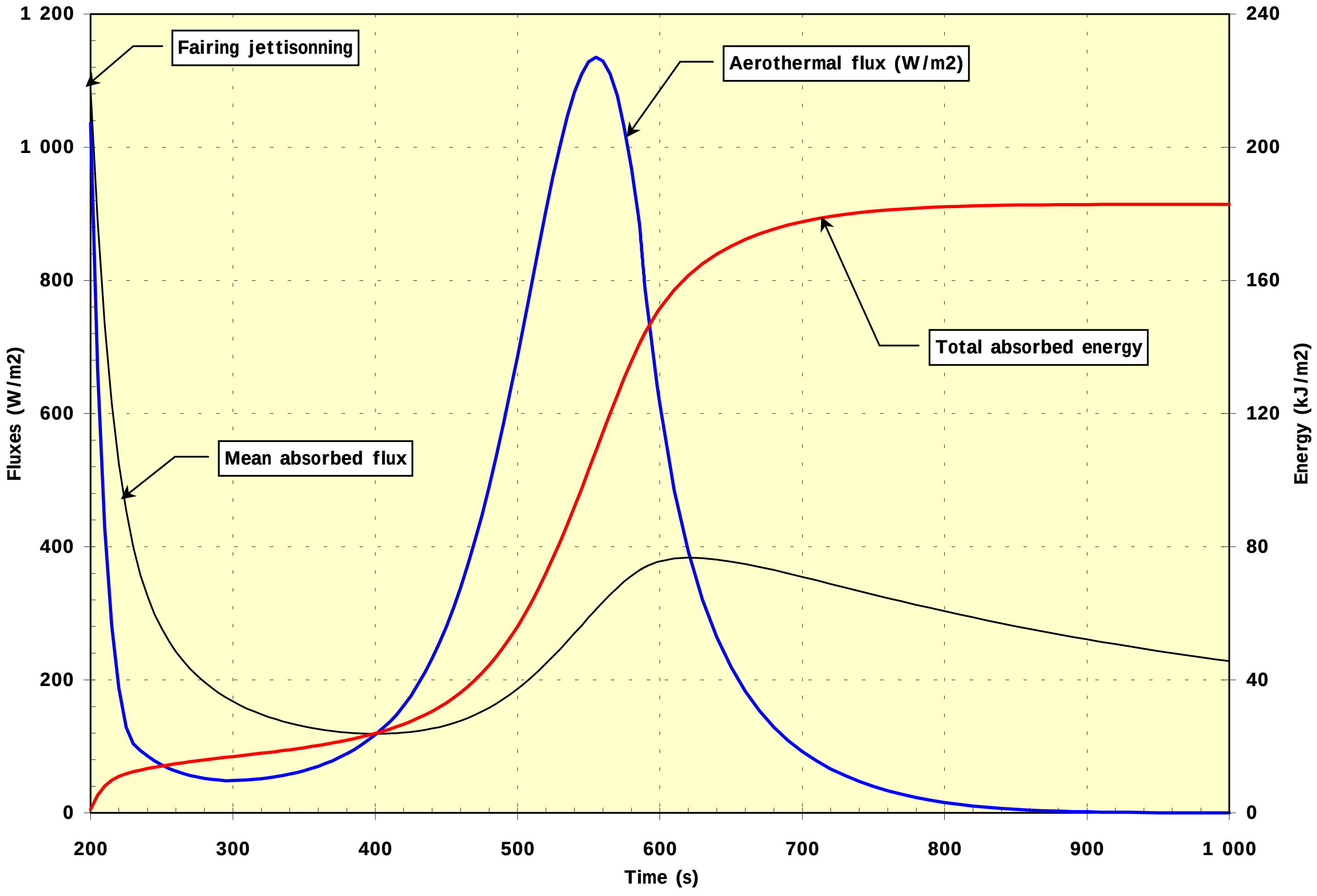


Figure 3.2.4.a– Aerothermal Fluxes on Standard ARIANE 5 G and ES Trajectory Fairing Jettisoning and Second Flux Peak Constrained at 1135 W/m2

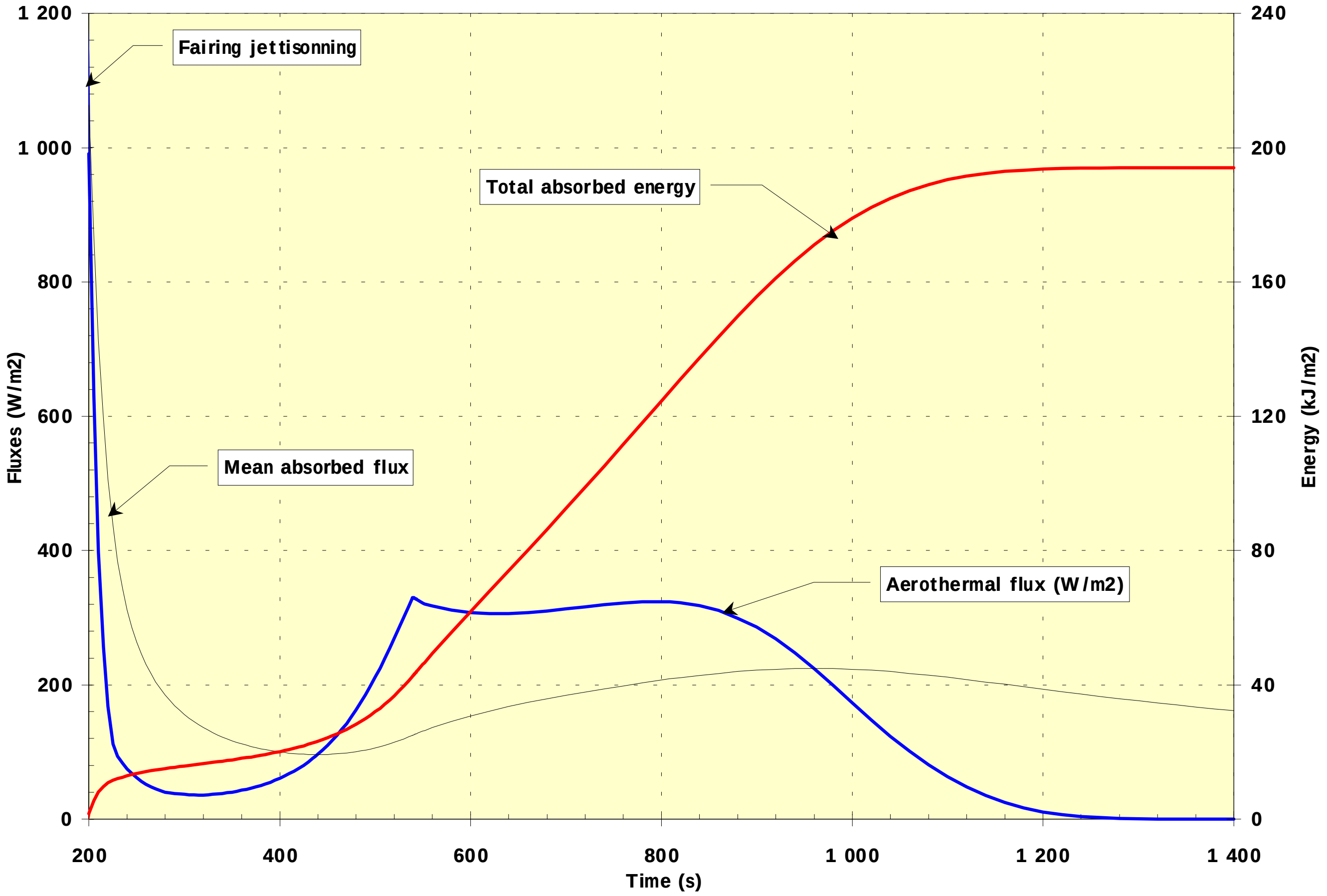


Figure 3.2.4.b – Aerothermal Fluxes on Standard ARIANE 5 ECA Trajectory Fairing Jettisoning Constrained at 1135 W/m^2

3.3. Variation of static pressure within the fairing, SPELTRA and SYLDA 5

The static pressure evolution is shown figure 3.3.a.

The typical slope is 20 mbar/s (locally 45 mbar/s during transonic phase).

3.4. Contamination and cleanliness

3.4.1. Organic contamination on the spacecraft

The clean rooms of BAF and EPCU buildings do not generate organic deposits exceeding 2 mg/m^2/week.

The launch structures, VEB, SPELTRA, Fairing, SYLDA 5 and adaptors are cleaned (cleaning and vacuum cleaning) before being set in container.

Ariane 5 and ELA 3 dot not generate organic deposits exceeding 4 mg/m^2 * on the spacecraft, from the begining of its encapsulation up to its separation from the launcher.

***Note**:
Made up of:

- material outgassing ≤ 2 mg/m^2,
- interstage separation system ≤ 2 mg/m^2,
- the fairing and SPELTRA and SYLDA 5 pyrotechnic separation systems are leak proof and do not cause any contamination.

3.4.2. Air cleanliness

In BAF and EPCU buildings, in the spacecraft containers (CCU), inside the fairing, SPELTRA or SYLDA 5, on the payload platform (PFCU) as well as during transfer between buildings, the air cleanliness class 100 000 is guaranteed.

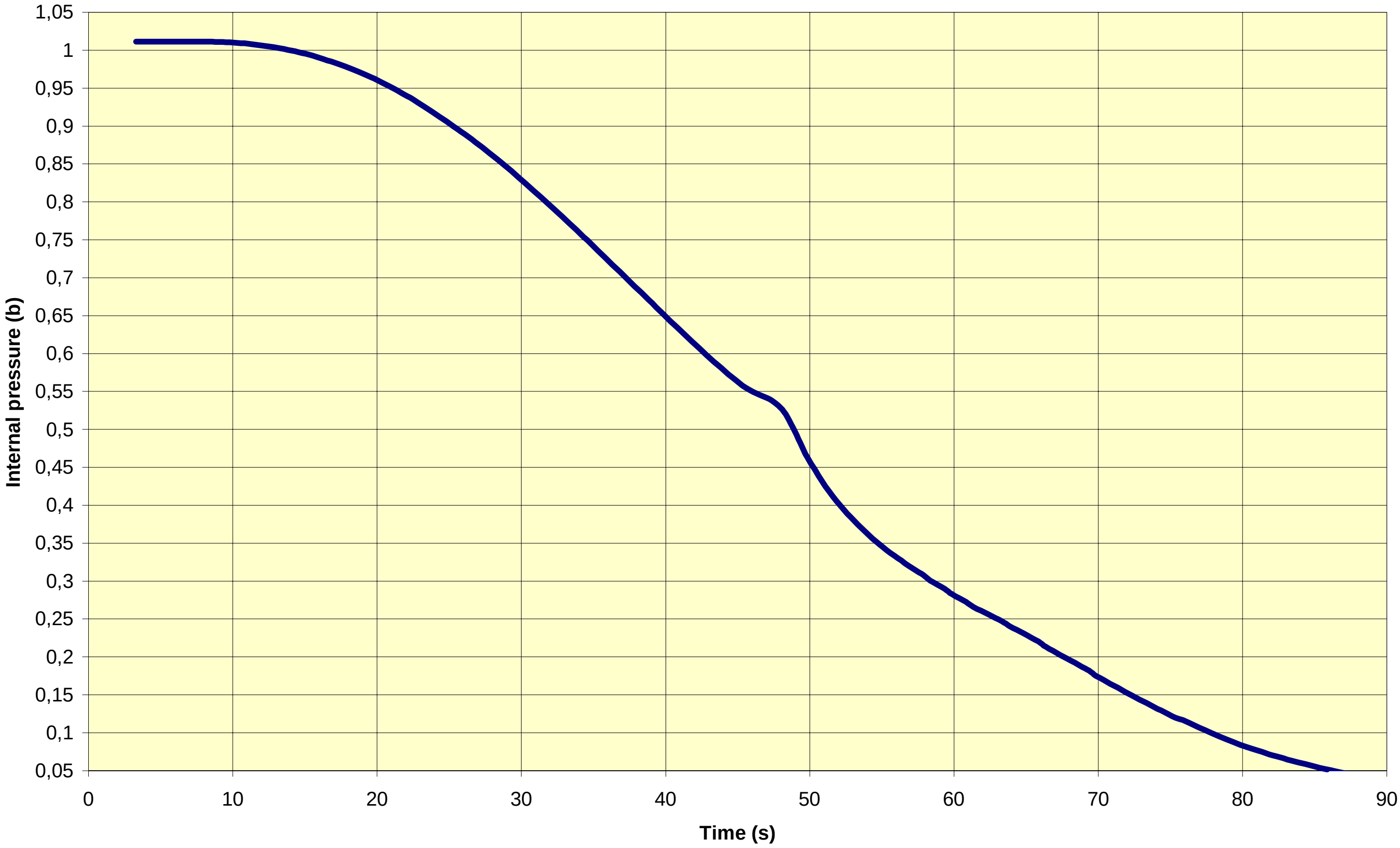


Figure 3.3.a – Variation of Static Pressure within Payload Volume

3.5. Radio and electromagnetic environment

In order to ensure the radio compatibility between the launch vehicle and the spacecraft, a frequency plan is drawn up for each launch. The user will be required to supply all data needed for the preparation of this plan within the "Application to use Ariane" document (see Annex 3).

Launcher

The launch vehicle is equipped with the following transmission and reception systems:

A telemetry system comprising two transmitters, each one coupled with a system of two antennae having an omnidirectional radiation pattern and respectively right and left-handed polarization. One transmitter is located in the VEB with its antennae fitted in the external section of the VEB. The second transmitter is located in the forward skirt of the cryogenic core stage with its antennae fitted on external part of skirt. The transmission frequency is in the 2200 – 2290 MHz band, and the transmitter power is 8 W. Allocated frequencies to the Launch Vehicle are: 2206.5 MHz, 2227 MHz and 2254.5 MHz, 2267.5 MHz, 2284 MHz.

A telecommand-destruct reception system, comprising two receivers operating in the 440 – 460 MHz band. Each receiver is coupled to a system of two antennae, located on the cryogenic core stage, having an omnidirectional pattern and no special polarization.

A radar transponder system, comprising two identical transponders with a reception frequency of 5690 MHz and transmission frequencies in the 5400 – 5900 MHz band. The minimum pulsed (0.8 μs) transmitting power of each transponder is 400 W peak. Each transponder is coupled to a system of two antennae, located on the cryogenic core stage, with an omnidirectional pattern and clockwise circular polarization.

Radiated levels (spurious or intentional) from the launch vehicle do not exceed those given in figure 3.5.a.

These levels are measured at 1 m below the 2624 reference bolted interface.

Range

The range electromagnetic environment of the CSG is measured every 18 months.

Spurious radiation interference levels from the launch vehicle and the CSG will not exceed those given in:

- Figure 3.5.a Spurious radiation: narrow-band electrical field.

These levels are measured at 1 m below the 2624 reference bolted interface.

Specific spurious radiations, emanating from the launch vehicle transmission systems, in particular from telemetry system, are lower than these levels (harmonics included).

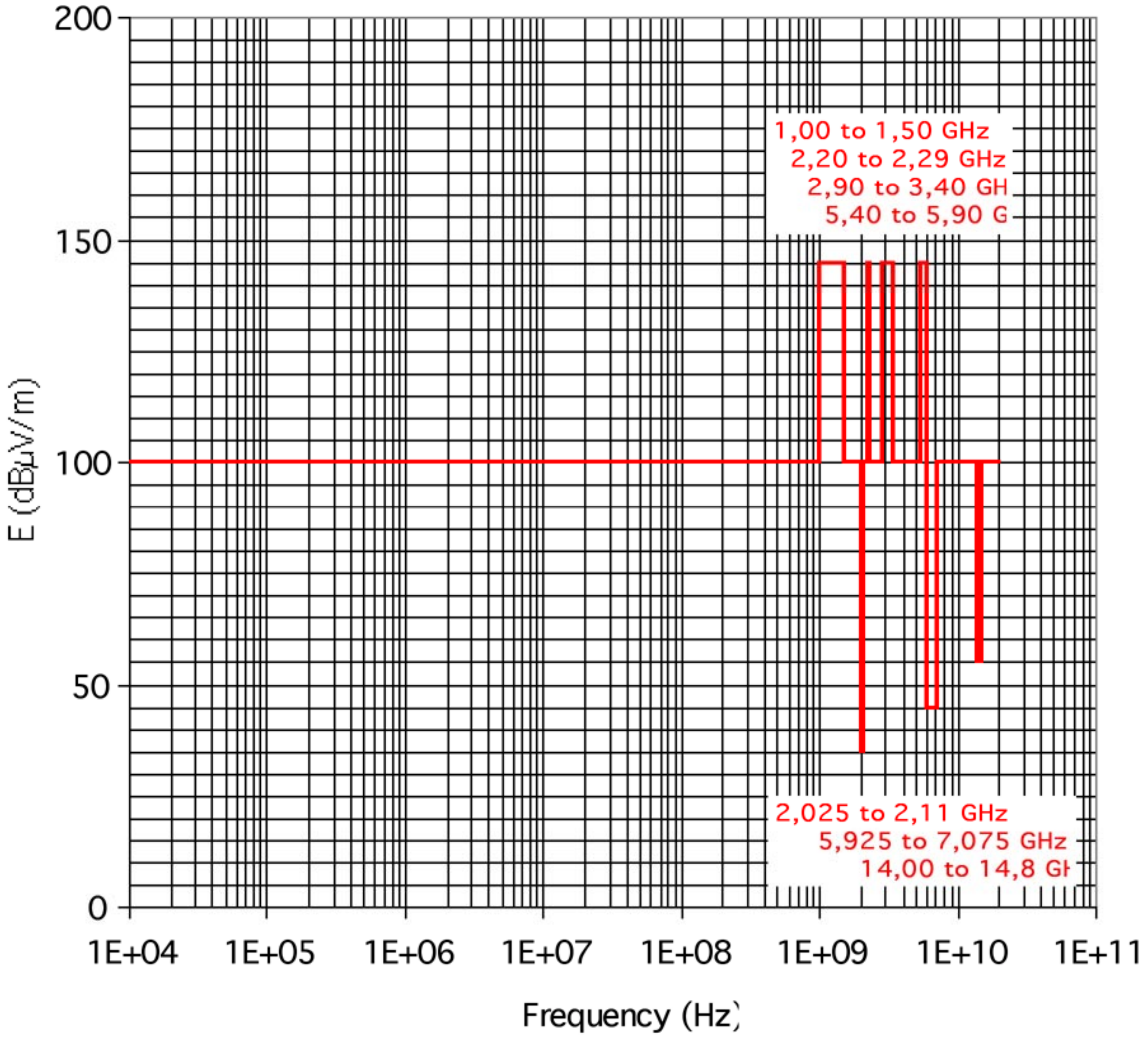


Figure 3.5.a – Spurious Radiation by Launch Vehicle and CSG Narrow-band Electrical field

Spacecraft design and dimensioning data

Chapter 4

4.1. Introduction

The design and dimensioning data that shall be taken into account by any User intending to launch a spacecraft compatible with the Ariane 5 launch vehicles are detailed in this chapter.

Figure 4.1.a shows the launch vehicle coordinate systems.

4.2. Safety requirements

The User is required to design the spacecraft in conformity with the CSG Safety Regulations.

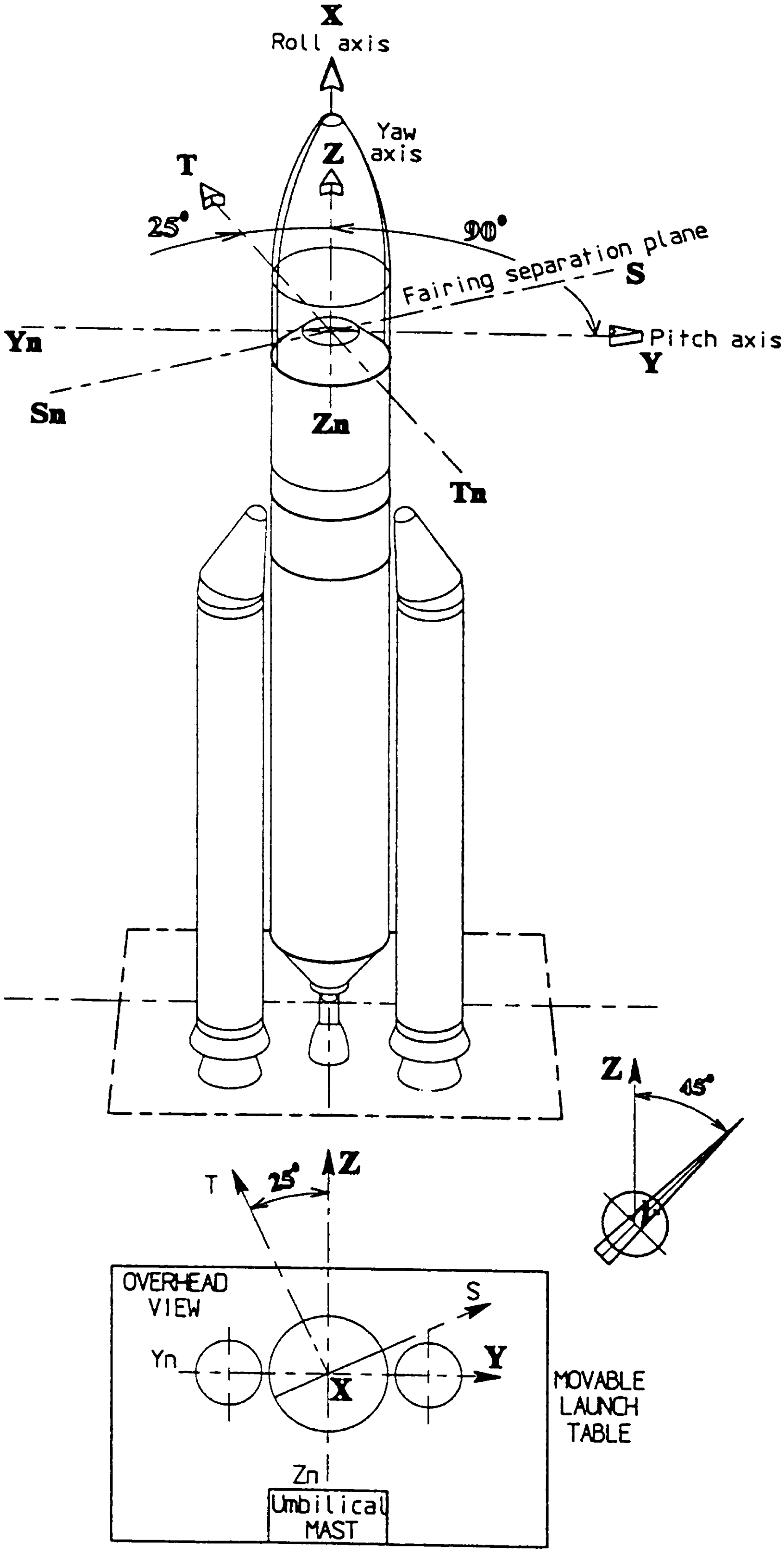


Figure 4.1.a – ARIANE 5 Launch Vehicle Axes

4.3. Mechanical interfaces

4.3.1. Payload compartment configurations

For a single spacecraft launch, one of the available fairing designs protects the spacecraft mounted on top of an adaptor which can be a standard Ariane or User's design.

For dual launch two configurations are available:

- SPELTRA configuration:
  - for the upper spacecraft position, the short fairing protects the spacecraft mounted on top of an adaptor (standard Ariane or User's design) fixed on to the SPELTRA upper interface flange,
  - for the inner position, the SPELTRA protects the spacecraft mounted on top of an adaptor (standard Ariane or User's design) fixed on the upper stage interface frange.

- SYLDA 5 configuration:
  - one of the short, medium or long available fairing designs protects the dual launch system SYLDA 5.

Nose fairing, SPELTRA and SYLDA 5 are described below.

- Nose fairing description:
  The Ariane 5 nose fairing consists of a two half-shell carbon fibre structure with a longitudinal Ariane type separation system. This nose fairing has an external diameter of 5,4 m.

  Separation of the nose fairing is obtained by means of two separation systems. An horizontal one (HSS) made of a pyrotechnical expansion tube (LCCD) that connects the fairing to the SPELTRA or to the upper stage, and a vertical one (VSS) that consists of a pyrotechnic cord, located close to the plane joining the two half-shells.

  This cord shears the rivets connecting the two parts, and imparts a lateral impulse to the half-fairings, driving them apart by a piston effect. The gases generated by the system are retained permanently inside an envelope, thus avoiding any contamination of the payload by the separation system. The HSS is fired first followed 1 ms later by the VSS.

- SPELTRA supporting structure description:
  The SPELTRA structure consists of a carbon fibre cylindrical shell of 4,1 m or 5,6 m length supporting the fairing and enclosing the inner spacecraft, and an upper troncated conical shell supporting the upper spacecraft.

  Separation of the SPELTRA structure is achieved by means of a Linear Charge Cord Device (LCCD) which cuts the SPELTRA structure along a horizontal plane, and springs impart a vertical impulse to jettison the SPELTRA-top.
  This supporting structure has an external diameter of 5.4 m.

- SYLDA 5 description:
  The SYLDA 5 consists of a load bearing carbon structure, comprising a conical adaptor to the Vehicle Equipment Bay (a cylindrical shell of variable length from 2,9 to 4,4 m by 300 mm steps) enclosing the inner spacecraft and an upper troncated conical shell supporting the upper spacecraft.

  Separation of the SYLDA 5 structure is achieved by means of a LCCD which cuts the SYLDA 5 structure along an horizontal plane at the level of the conical/cylindrical lower interface. Springs impart an impulse to jettison the SYLDA 5.

Note: ∅ 5 400 mm extension structures (ACY 5400) allow to adapt the existing fairing, SPELTRA or SYLDA 5 to the customer need (see figure 4.3.1.c).

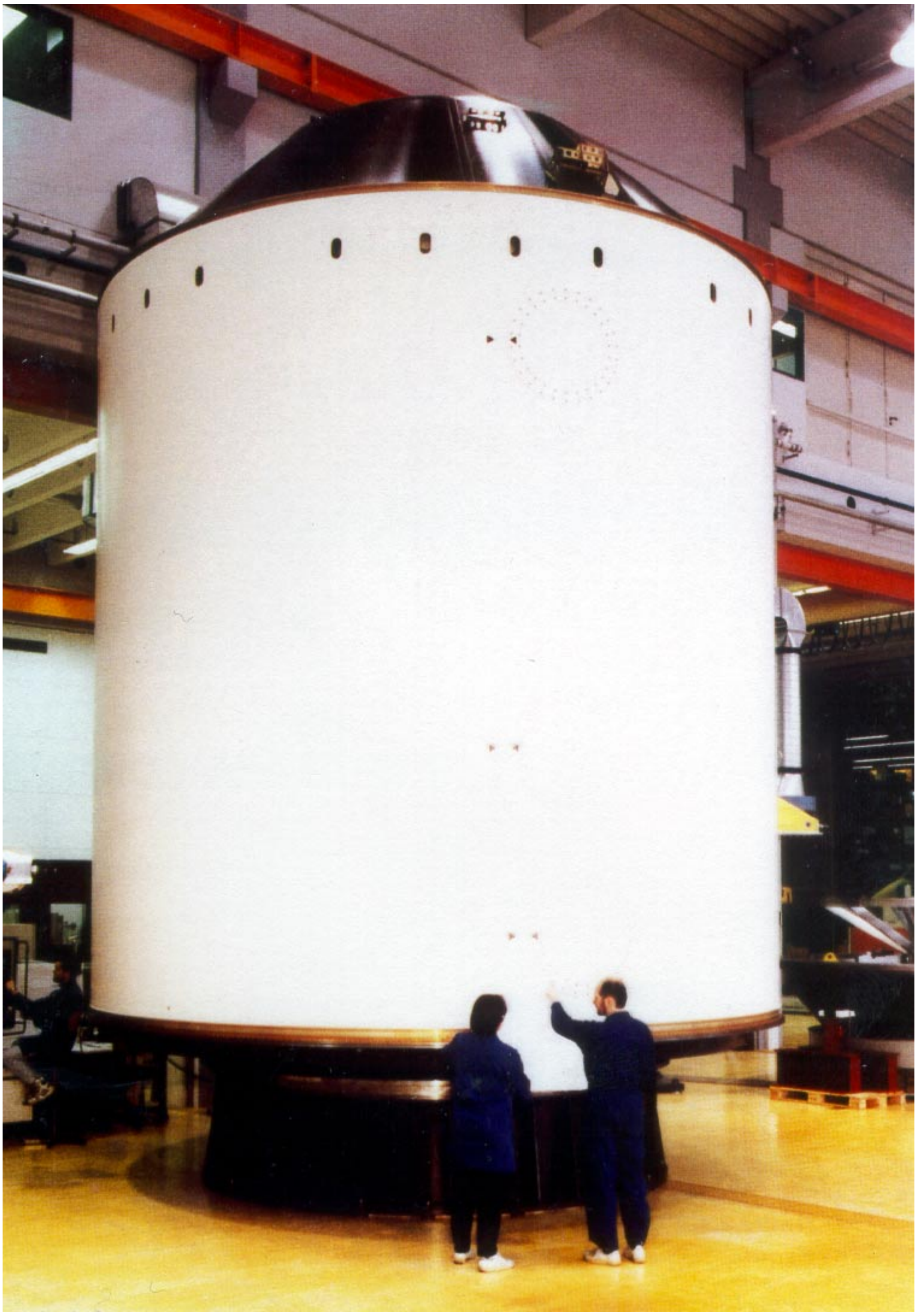


Figure 4.3.1.a – SPELTRA – External Carrying Structures

Figure 4.3.1.b – SYLDA 5 – Internal Carrying Structures

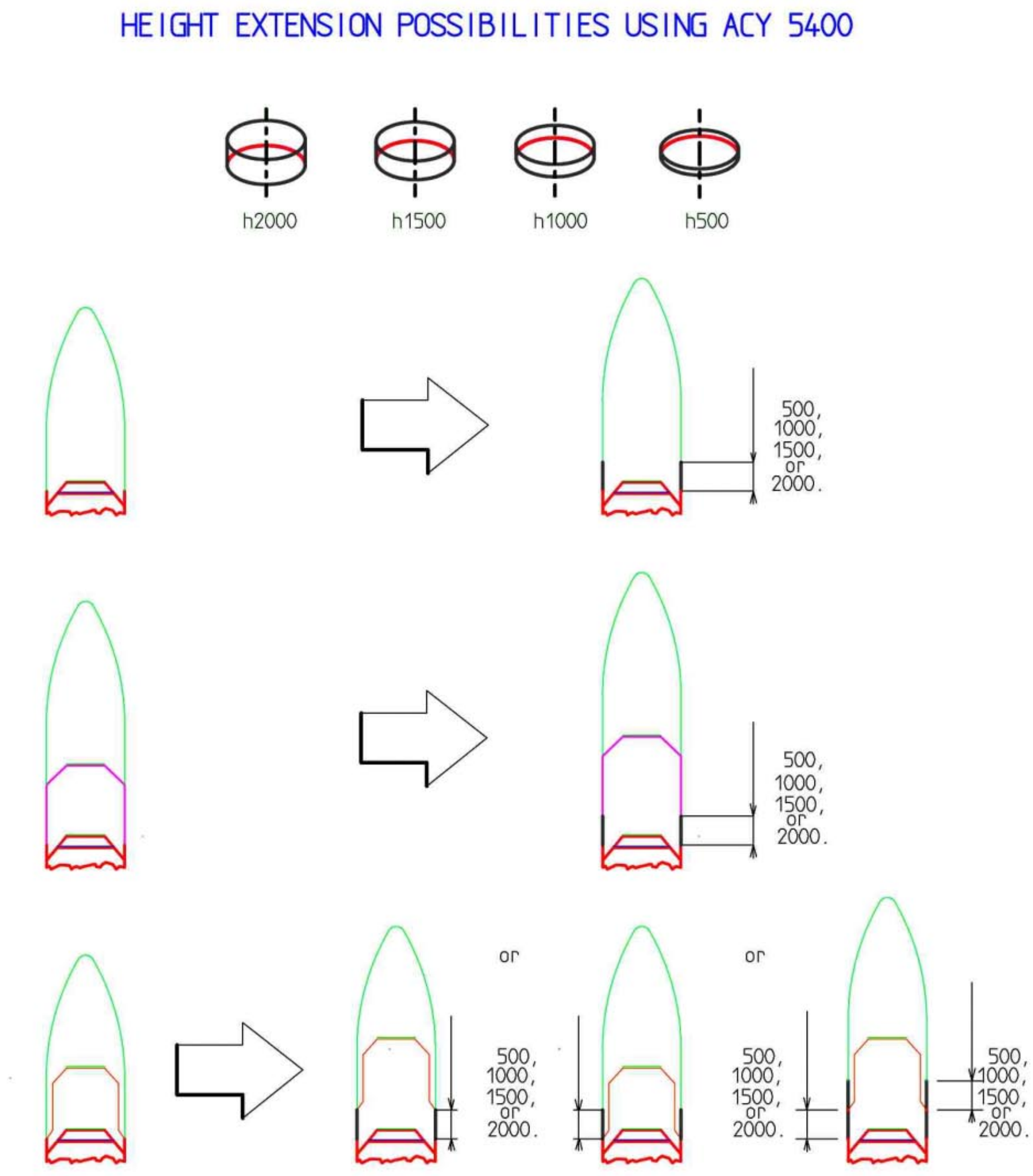


Figure 4.3.1.c. – Extension Possibilities using ACY 5400

4.3.2. Spacecraft accessibility

Spacecraft accessibility is provided through the fairing and carrying structures (SPELTRA and SYLDA 5). For details, refer to Annex 4.

4.3.3. Launch vehicle/spacecraft adaptors

4.3.3.1. Introduction

The spacecraft is mounted on the top of the launch vehicle via an adaptor.

The standard interface plane between the launch vehicle and the spacecraft is the bolted interface plane with a diameter of 2624 mm. For mounting a spacecraft on this 2624 interface, the User can either utilize one of the standard Ariane adaptors in which case the spacecraft separation system is provided with the Launch Vehicle, or utilize any other type of adaptor compatible with this interface, in which case the separation system has to be provided by the User.

Standard Ariane adaptors (including SYLDA 5) form part of the launch vehicle. Other adaptors may be designed and manufactured by the User to mate with the bolted interface planes.

For multi-launch configurations, Arianespace proposes the ASAP 5 structure for auxiliary payloads up to 120 or 300 kg depending on launch configuration (see ASAP 5 User's Manual) and various types of dispensers as described in the annex 12.

A purging interface at the spacecraft interface can be provided. It is available up until lift-off. Customer whishing to exercise this option are requested to contact ARIANESPACE for further details.

4.3.3.2. Standard Ariane adaptors (see annexes)

- Adaptors 1194V, 1194H.
- Adaptors 937V5 (shoe angle 20°).
- Adaptors 937VB5 (shoe angle 15°).
- Adaptor 1663SP5.
- Adaptor 1666V.
- Adaptor 2624.
- Dispensers.
- ACY2624:
  ∅ 2624 mm raising cylinders with heights ranging from 500 ter 1000 mm (mass from 75 to 95 kg).

4.3.3.3. Adaptors mounted on the 2624 diameter interface plane

Other adaptors than those described in the User's Manual can be used on Ariane. In such a case, the specification requirements are to be requested to Arianespace.

4.3.4. Usable volume

Refer to annex 5.

4.3.5. Bolted interfaces

4.3.5.1. ∅ 2624 mm

The ∅ 2624 mm bolted interface is available for single and dual (upper and lower positions) configurations.

It warrants the interface between the upper stage, SPELTRA, SYLDA 5 upper frame and the spacecraft adaptor lower frame.

It consists of 244 holes M8 (equally spaced) on a ∅ 2624 mm.

The payload usable volume (spacecraft + user's adaptor) is defined in the figure 4.3.5.1.a for single launch and in figure 4.3.5.1.b for dual launch.

For some particularly heavy payload a specific adaptor may be necessary ("cone" 3936) its mass is 230 kg. See Annex 11.

4.3.5.2. ∅ 3936 mm

The ∅ 3936 mm bolted interface is available for single launch configuration.

It warrants the interface between the upper stage upper frame and the spacecraft adaptor lower frame.

It consists of 386 holes M8 on a ∅ 3936 mm.

The payload usable volume (spacecraft + User's Adaptor is defined for the single launch configuration in the 4.3.5.2.a.

It is designed for a mass of 18 000 kg with a Centre of Gravity at 6 m.

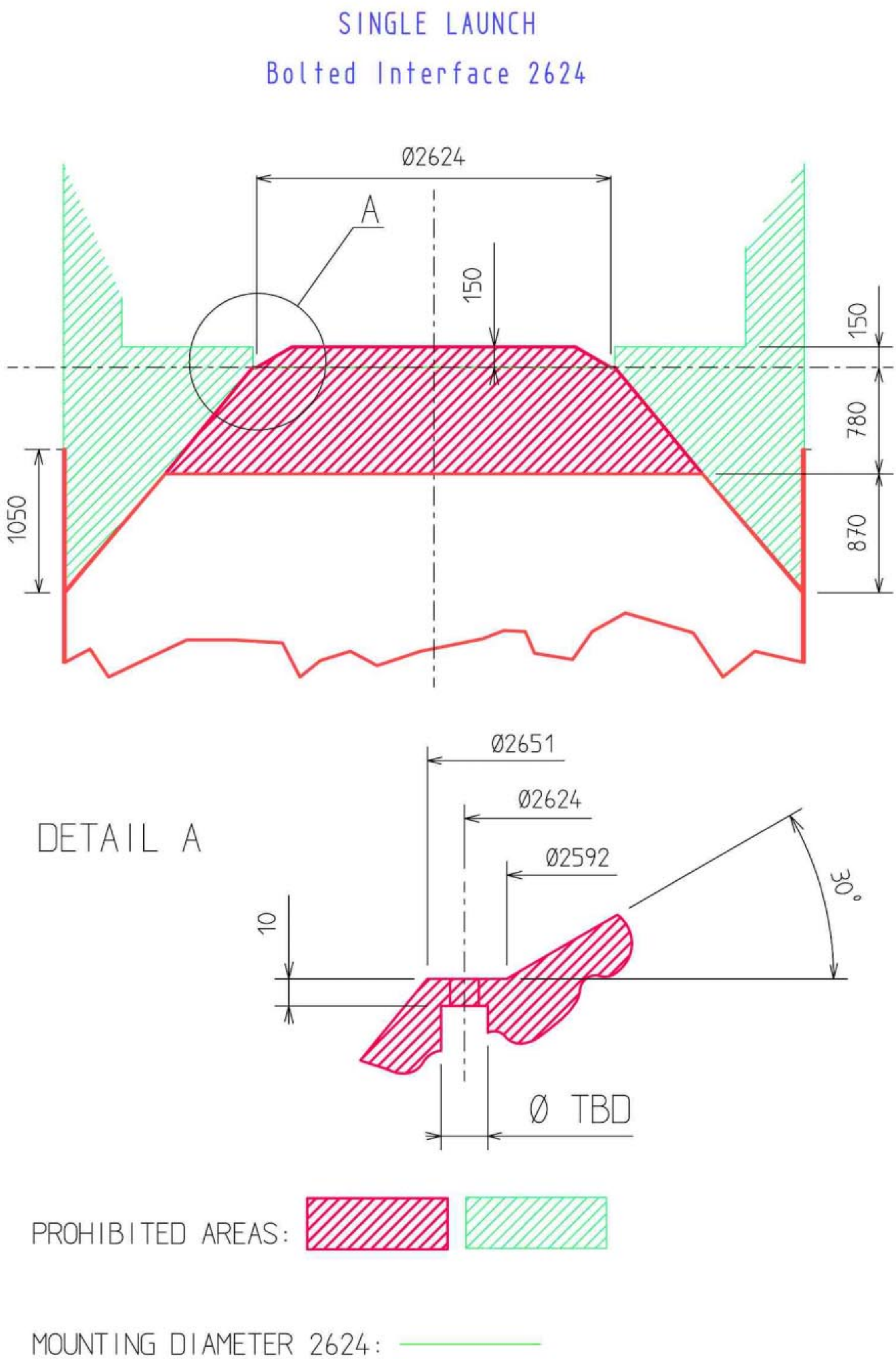


Figure 4.3.5.1.a – Single launch bolted interface 2624

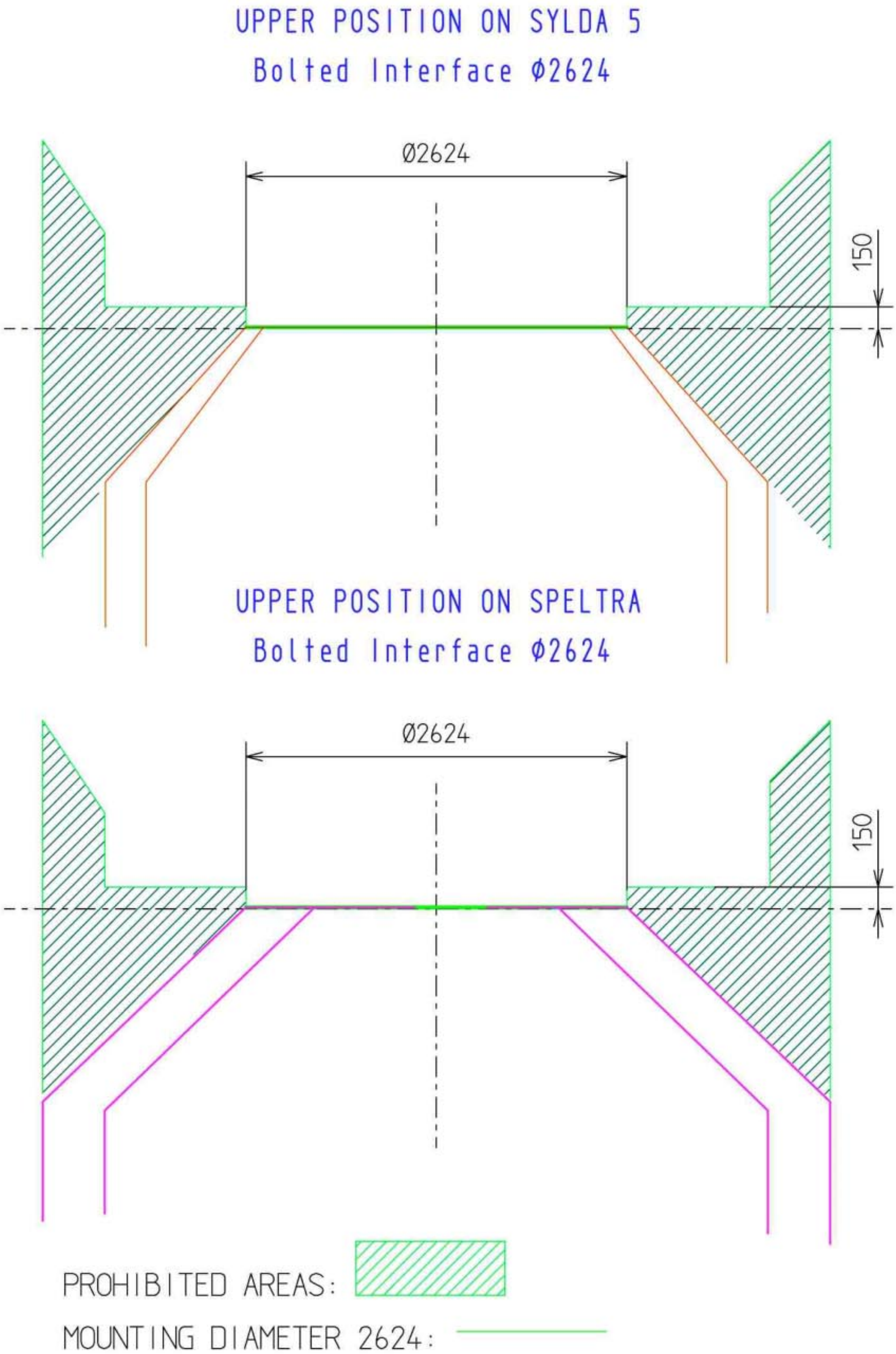


Figure 4.3.5.1.b – Dual Launch Bolted Interface 2624

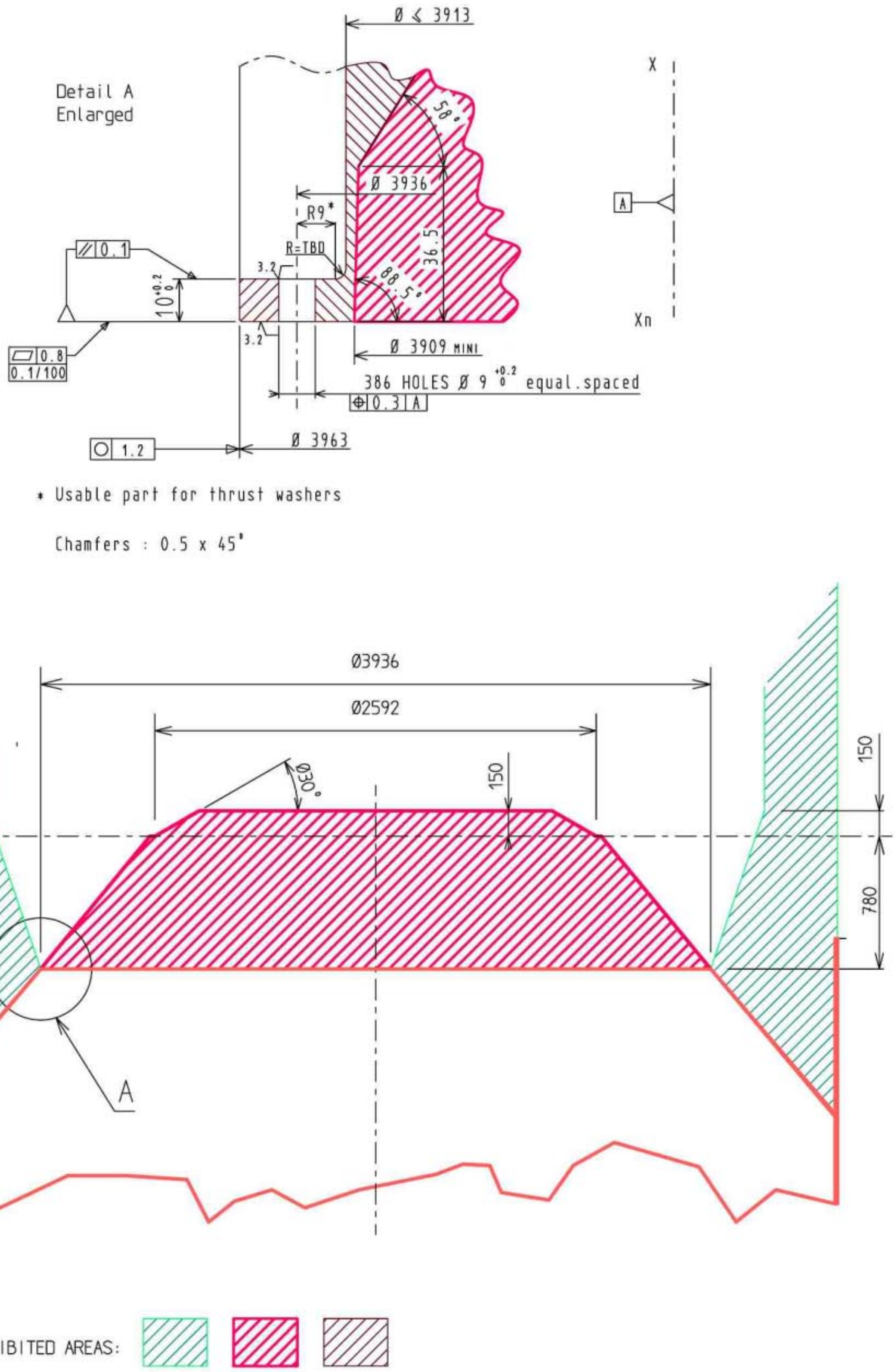


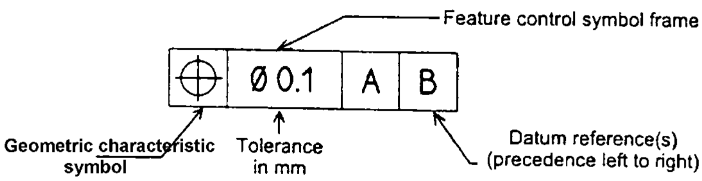
Figure 4.3.5.2.a – Single Launch Bolted Interface 3936

GEOMETRIC CHARACTERISTIC SYMBOLS:
Symbols for shape and tolerances extracted from R.E. AERO 772 75 specification approved by BNAe.

CHARACTERISTIC		SYMBOLS
Form tolerances	- Straightness	⏤
	- Flatness	⏥
	- Roundness	○
	- Cylindricity	⌭
	- Profile of a line	⌒
	- Profile of a surface	⌓
Location tolerances	- Angularity	∠
	- Perpendicularity	⟂
	- Parallelism	∥
	- Position	⌖
	- Concentricity	◎
	- Symmetry	⌯
	- Run out	↗

A control symbol label is attached to the item subjected to the tolerance. This label provides for the necessary positions to specify the control symbols.

Example:

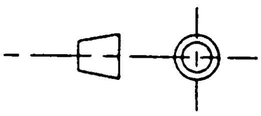


Basic dimension:

$\boxed{12}$ Theoretically exact dimension without tolerance

Surface roughness symbol:
1.6 maximum value (when not otherwise specified) expressed in micrometers. (1 μm = 0.001 mm)

Projection:



Inertias
Relatives to axes parallels to the launch vehicle passing through the center of gravity of the considered section.

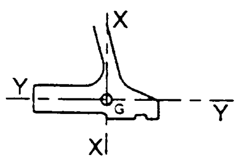


Figure 4.3.5.3 – Explanation of Symbols and Topics

4.4. Electrical and radio electrical interface

4.4.1. Earth-potential continuity

The spacecraft is required to have an « Earth » reference point close to the separation plane, on which a test socket can be mounted. The resistance between any metallic element of the spacecraft and a closest reference point on the structure shall be less than 10 mΩ for a current of 10 mA.

Spacecraft structure in contact with the launch vehicle (separation plane of the spacecraft rear frame or mating surface of an user's adaptor) shall not have any treatment or protective process applied which creates a resistance greater than 10 mΩ for a current of 10 mA between the spacecraft earth reference point and that of the launch vehicle (Ariane adaptor or carrying structure).

4.4.2. Services available at the base of spacecraft adaptor

This section defines the electrical services, which the User may request at the base of the spacecraft/launcher interface.

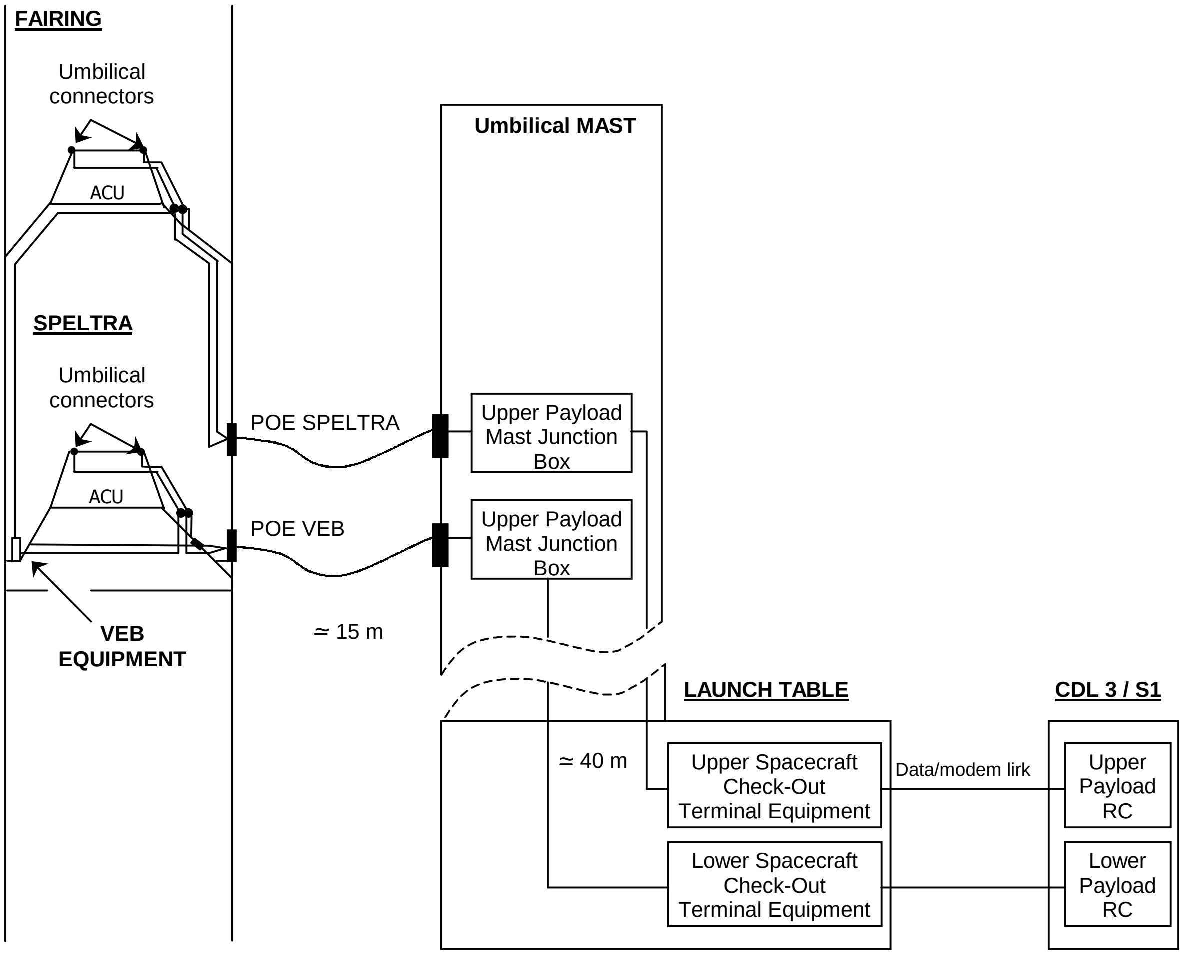
Some of these services are standard (Std), others are optional (Opt). The mode of access to the service at the interface and the related descriptive paragraph references are as follows:

Service	Service definition	Type	S/C Interface
UMBILICAL LINK	74 wires	Standard	2 x 37 pin connectors* DBAS 70 37 OSN DBAS 70 37 OSY
COMMANDS	Dry loop command Electrical command	Standard	
TELEMETRY	Separation status	Standard	
	Spacecraft data transmission	Option	
ELECTRICAL SUPPLY	Power supply	Option	
COMMANDS	Pyrotechnic command	Option	2 x 12 pin connector DBAS 7012 OSN DBAS 7012 OSY

* **<u>Note</u>:** 2 x 61 PIN CONNECTORS CAN BE ACCEPTED; among these pins, two (one per connector) are left free for shielding.

4.4.2.1. Umbilical Link

The principle of the umbilical links between a payload on top of Ariane and its electrical support equipment located in the CDL is shown on figure 4.4.2.1.1.



4.4.2.1.a. – Available lines between S/C in launch zone and the CDL during the final count down phase

Between the base of the payload adaptor and the umbilical mast junction box, 74 wires will be made available for each payload including 3 high bit rate links (1 M bits/s).

The characteristics of these umbilical linkes are:
- T.B.D.,
- insulation > 5 MΩ under 500 Vdc.

Operating constraints:

- The wired connectors shall not carry current in excess of 5 A.
- The voltage is ≤ 120 Vdc.
- No current shall circulate in the screens.
- The spacecraft wiring insulation is > 10 MΩ under 50 Vdc.
- Spacecraft wiring insulation: > 10 mΩ under 50 V dc.
- Wiring diagram refer to figure TBD.

4.4.2.1.1. Separation command

The pyrotechnic command for spacecraft separation is a standard service supplied by the launch vehicle.

Normally 2 redundant commands (4 squibs) are necessary for the separation of the spacecraft.

Should the spacecraft provide its own separation system the pyrotechnic command will be generated by the launch vehicle. The electrical characteristics of the initiators must be identical to the characteristics of the initiators used on the launch vehicle. The user designing its own separation system should contact Arianespace to obtain details on the commands and initiators requirements.

4.4.2.1.2. Pyrotechnic command

4 pyrotechnic commands can be available for a User's pyrotechnic system other than the separation system.

Each command can initiate 1 squib and is fully redundant, i.e. two totally separate lines provide the same command simultaneously, the power being supplied from separate batteries.

These commands are segregated from the umbilical links and other commands by means of specific connectors.

4.4.2.1.3. Main electrical characteristics

- Voltage (no-load): 28 V ± 4 V.
- Pulse Width: 50 ms ± 10 ms.
- Output insulation: ≥ 200 MΩ.
- Current: 5 A (or standing squibs: 1.05 Ω/5 minutes).

Interval between 2 commands: the minimum time interval between the end of a transmitted command and the beginning of the following one is T.B.D.

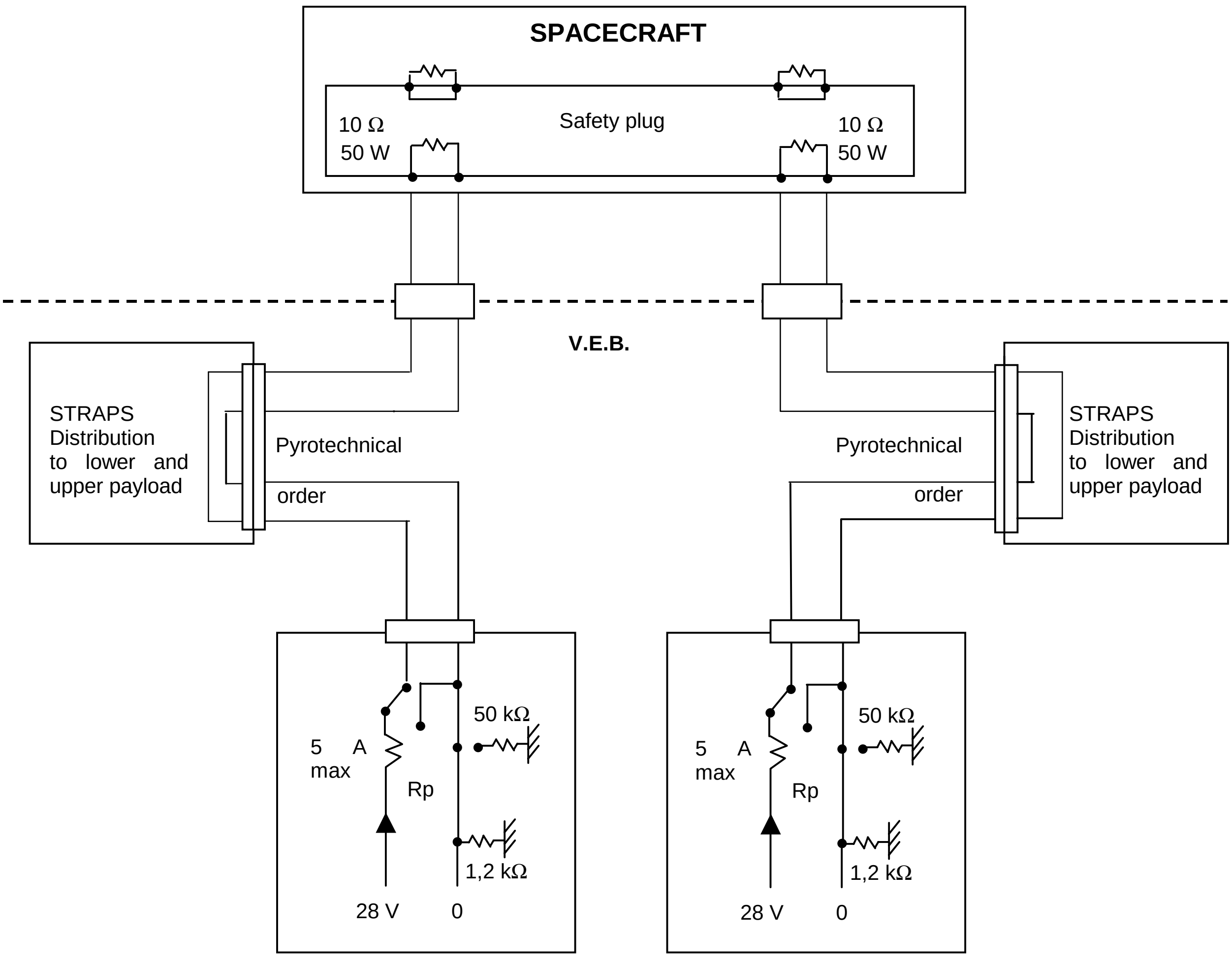
The execution of the pyrotechnic command (pyrotechnics voltage at sequencing unit output) is transmitted to the ground via telemetry.

The insulation between wires (open loop) and between wires and structure must be ≥ 100 k Ω (under 50 Vdc).

The user has to intercept the launcher command circuits (prime and redundant) in order:

- to protect the S/C equiment,
- to allow the integration check-out.

Using a safety plug equipment with a shunt on S/C side and a resistance of 10 Ω ± 1% (50 W) on the L/V side.



Pyrotechnical command diagram

4.4.2.2. Electrical and dry-loop commands

Electrical and dry-loop commands are available, with the characteristics defined here below.

Per spacecraft, 6 redunded commands are available for electrical and dry-loop commands.

4.4.2.2.1. Dry-loop commands

Main electrical characteristics:

R off ≥ 100 kΩ
R on / on board ≤ 1 Ω
Launcher on board circuit insulation ≥ 1 M Ω under
50 Vdc.

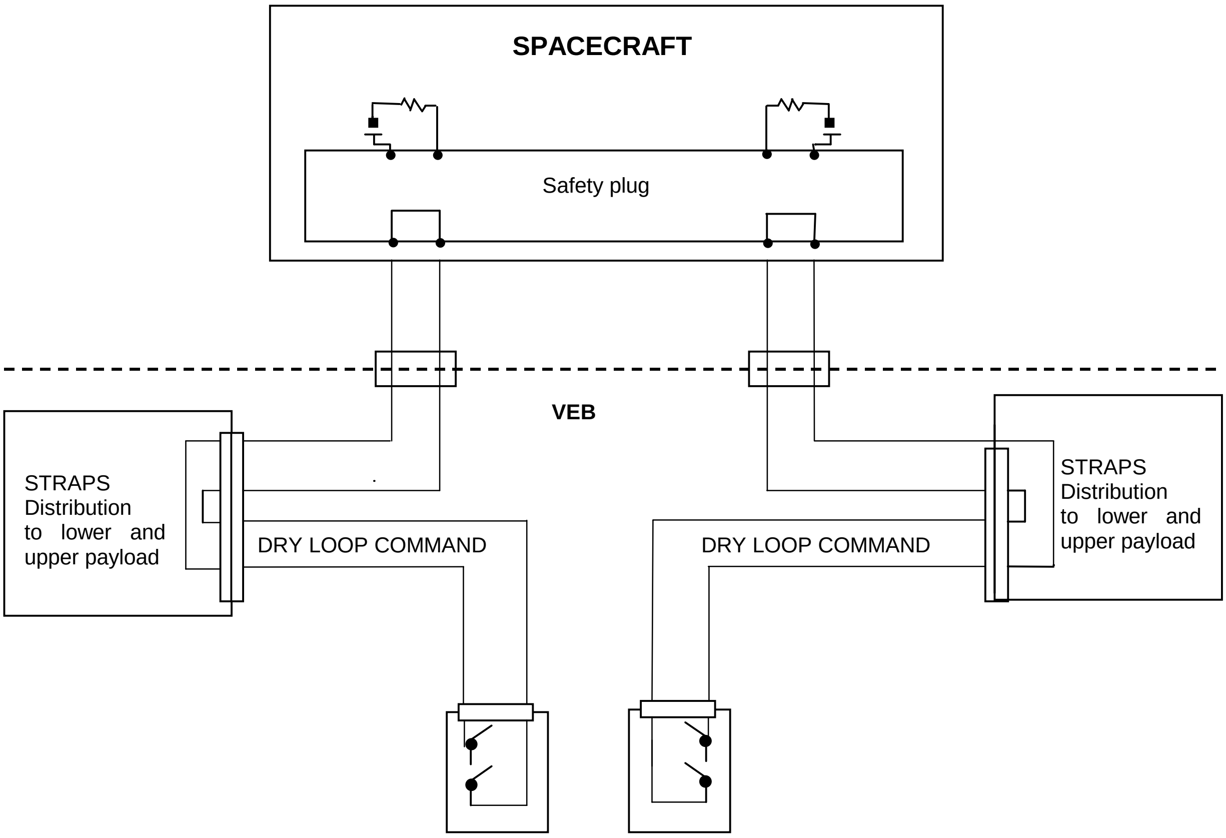
Protection

The user is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switchings and in the case of circuit degradation.

The user has to intercept the launcher command units (prime and redundant) in order:

- to protect the S/C equipment,
- to allow the integration check-out

using a safety plug equipped with an open circuit on the S/C side and a short circuit on the L/V side.



Utilization constraints (S/C side)

U Max ≤ 50 V
I Max ≤ 0.5A (If the user request I > 0.5A) please contact ARIANESPACE)

Dry loop command diagram

4.4.2.2.2 Electrical command

The main electrical characteristics of these redundant commands are:

- output voltage 28 V ± 4 V.

- I ≤ 0.5 A (if the User requests I > 0.5 A please contact Arianespace).

<u>Protection</u>

The user is required to protect the circuit against any overload or voltage overshoot induced by his circuits both at circuits switchings and in the case of circuit degradation.

The user has to intercept the launcher command units (prime and redundant) in order:
- to protect the S/C equipment,
- to allow the integration check-out

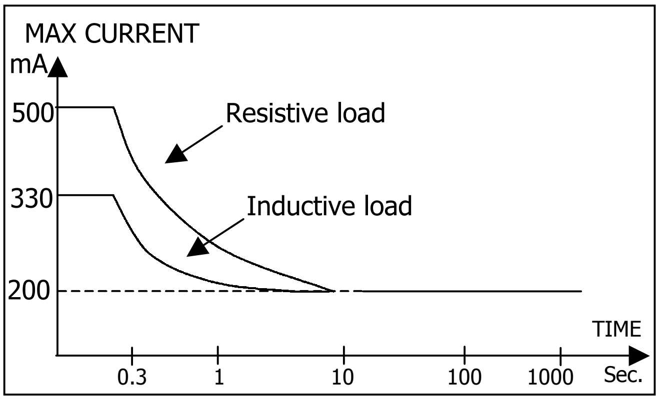
using a safety plug equipped with an open circuit on the S/C side and a short circuit on the L/V side.

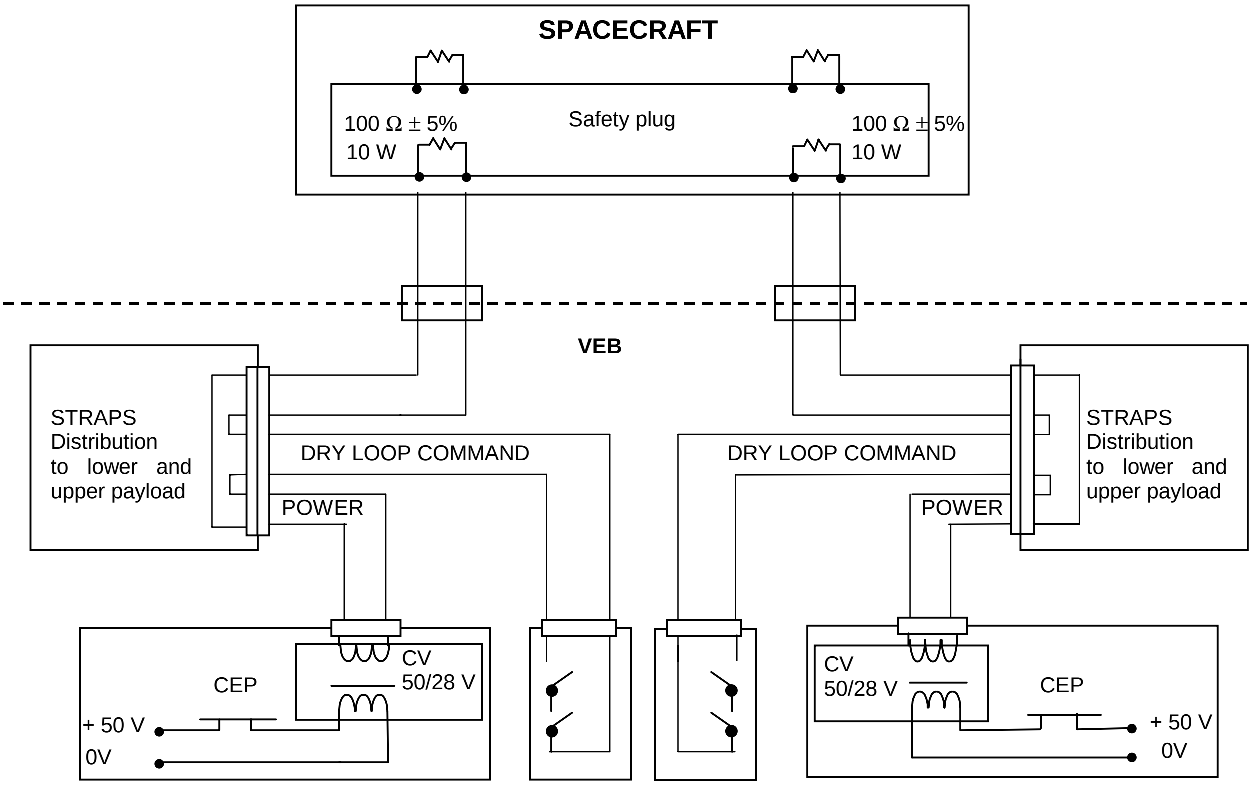
<u>Main utilization constraints (S/C side)</u>

- The user is required to use two independent loads, one on each redundant line. If a unique load is used, then a protection circuit is necessary up-stream of the summing-up points.

- Each circuit must be in compliance with the following constraints:

Current/time characteristics:
The user is required to dimension his load circuit so that the current drawn remains below the following curve.





Electrical command diagram

4.4.2.3. Separation Status

The VEB telemetry system sends status a signals of the spacecraft separation. Signals are initiated at the interface by microswitches.

4.4.2.4. In Flight Telemetry

Transmission of data on the in-flight dynamic environment at the interface plane with the User is performed by the VEB Telemetry system. Transducers are provided with standard Ariane adaptors.

Should a User supply the adaptor, Arianespace will supply the User with transducers to be installed on the adaptor close to the interface plane.

The provision of facilities for the in-flight transmission of spacecraft measurements can be studied, as an optional service, on a case by case basis. A User wishing to exercise such an option should contact Arianespace for interface characteristics.

4.4.2.5. Power supply

A power supply is available to the User, as an optional service.

The characteristics are:

- 28 V ± 4 V ; 1.6 Ah

I max ≤ 0.5 A (if the User requests I > 0.5 A please contact Arianespace).

A non-standard voltage can be made available for an electric command. The user should contact Arianespace for this option.

4.4.2.6. Electrical interface on standard Ariane adaptors

Standard Ariane adaptors are equipped with harness providing connections between the services available at the adaptor 2624 mm mounting plane, as described in the para. (4.4.2) and the spacecraft interface connectors.

On the spacecraft side, the umbilical connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

Note: Arianespace will supply the User with the spacecraft side interface connectors with which standard adaptors have been qualified.

4.4.3. Radio and electromagnetic constraints

4.4.3.1. Fairing, SPELTRA and SYLDA 5 transparency for spacecraft radio-communications

- Radiotransparency of fairing and SPELTRA can be achieved through radio transparent windows for fairing and through access doors for SPELTRA enabling radio links to be maintained between spacecraft and ground support equipment. The insertion loss of the material used for a window will be less than 2 dB in the 2 GHz – 15 GHz frequency range.

- Radio transparency through SYLDA is ensured by holes in the structure.

The locations and dimensions of fairing and SPELTRA radio transparent windows or SYLDA5 access holes are given in annex 4.

- A passive repeater system can also be installed inside the SYLDA 5, SPELTRA or the fairing. It is composed of 2 cavity back spiral antennae and it is linked to the launch tower until lift-off.

4.4.3.2. Operating constraints

- The spacecraft shall not radiate a narrow-band electrical field at 0.5 m below the ∅ 2624 mm bolted interface exceeding the limit set in figure 4.4.3.2.a. (including intentional transmission).

- A 35 dBμv/m level radiated by the spacecraft, in the launch vehicle telecommand receiver 420-480 MHz band, shall be considered as the worst case of the sum of spurious level over a 100 kHz bandwidth.

- Spacecraft transmitters have to meet general IRIG specifications.

4.4.4. Electrical and radio requirements for the launch phase

- Electrical requirements:
  The User shall so design his spacecraft that during the final preparation phase leading up to actual launch, the umbilical cables are carrying only low currents at the moment of lift-off, (i.e. less than 100 mA – 85 V and a maximum power limitation of 2 W. Spacecraft power shall be switched from external to internal and ground power supply must be switched off before lift-off.

- Radio requirements:
  There is a restriction on spacecraft transmissions up to 20 s after separation of spacecraft. Authorization to allow transmission during the countdown phase and/or flight phase and/or at spacecraft separation will be considered on a case by case basis.

  The housekeeping telemetry and telecommand of the spacecraft may be subject to change on request of Arianespace up to 20 months before launch.

  The spacecraft telemetry frequency band must not overlap the launch vehicle bands: 2206.5 MHz, 2227 MHz, 2254.5 MHz, 2267.5 MHz, 2284 MHz.

- Flight constraints:

  During the powered phase of the launch vehicle and up to separation of the payload(s), no telecommand signal can be sent to the payload(s), or generated by a spacecraft on board system (sequencer, computer, etc...).

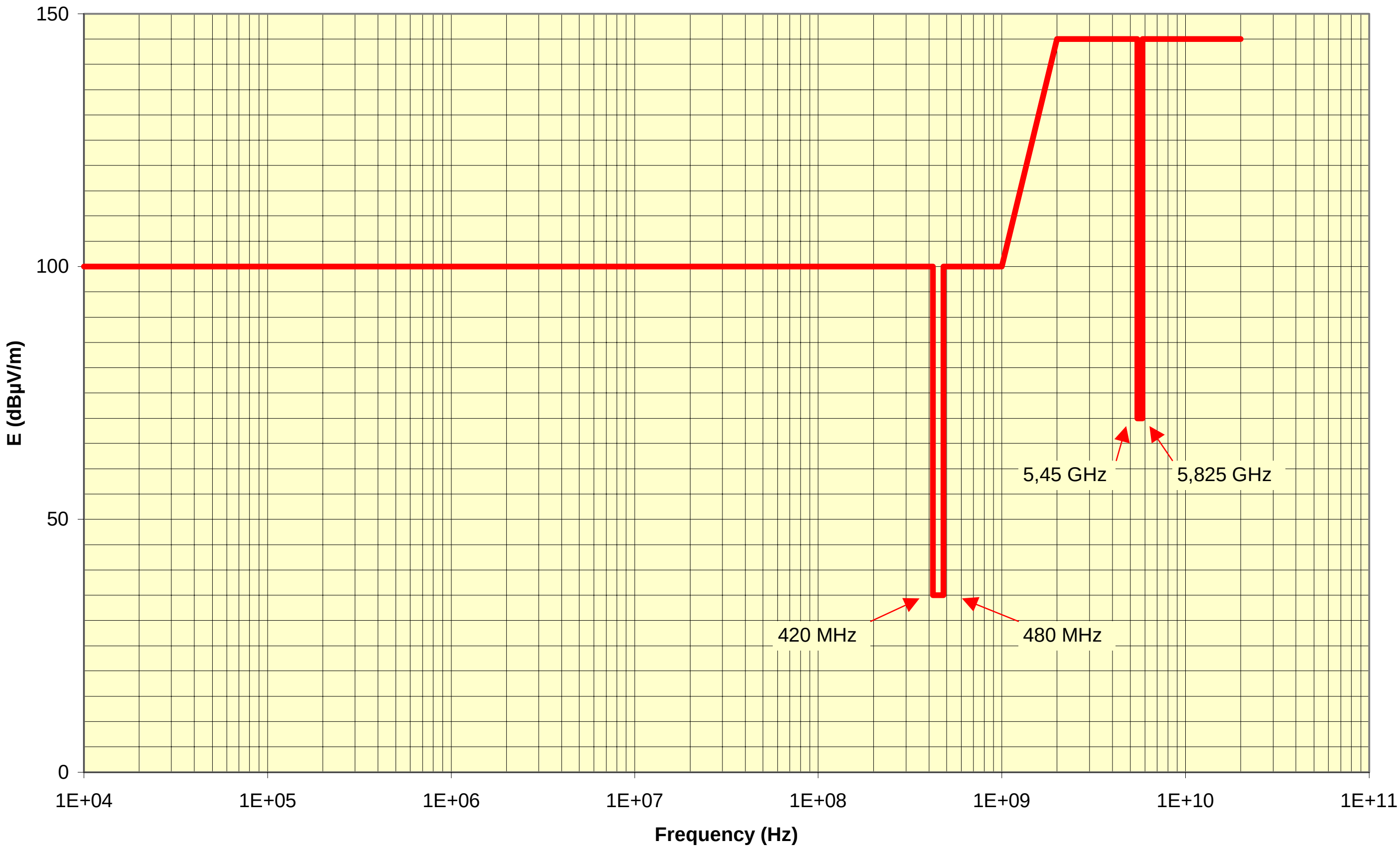


Figure 4.4.3.2.a. – Spurious radiations acceptable to launch vehicle Narrow-band electrical field

4.5. Dimensioning

This chapter defines the spacecraft design data and dimensioning criteria that shall be taken into account by any User intending to be compatible with Ariane 5 launch vehicles.

In the following paragraphs the spacecraft station is defined as the top of the adaptor used.

4.5.1. Selection of spacecraft materials

The spacecraft materials must satisfy the following outgassing criteria:

- Total Mass Loss (TML) ≤ 1 %,
- Collected Volatile Condensable Material (CVCM) ≤ 0.1 %.

measured in accordance with the procedure "ESA PSS-01-702".

4.5.2. Center of gravity limits

See annexes refering to adaptors.

4.5.3. Spacecraft balancing

4.5.3.1. Static inbalance

a) Spun-up spacecraft
In the same three-axis system O, X, Y, Z, the centre of gravity of the spacecraft must stay within a distance d ≤ 30 mm from the axis OX.

b) Three-axis stabilized spacecraft
The static unbalance varies with the spacecraft mass as follows:

Spacecraft mass Mcu (kg)	d (m)
MCU ≤ 4500 4500 ≤ MCU ≤ 18000	< 0.03 0.03 < d < 0.15*

* linear function of the mass.

4.5.3.2. Dynamic inbalance

For spacecraft which require to be spun up, the maximum dynamic inbalance ε corresponding to the angle between the spacecraft longitudinal geometrical OX-axis and the principal roll inertia axis shall be:

ε ≤ 1 degree.

It should however be kept in mind that this parameter is in direct relationship with the angular transverse rate after separation.

4.5.4. Frequency requirements

To avoid dynamic coupling between the low-frequency vehicle and spacecraft modes, the spacecraft should be designed with a structural stiffness which ensures that:

4.5.4.1. Lateral frequencies

The fundamental frequency in the lateral axis must be as follows:

a) If the User supplies its own adaptor:

Please contact Arianespace.

b) If Ariane adaptor is used:

Launcher S/C Separation Interface	Satellite mass (kg)	Lateral fundamental (*) Frequency (Hz)
∅< 2624 mm ∅ 2624	See annexes defining the adaptors M ≤ 4500	> 10 ([1]) > 9

This assumes a spacecraft hardmounted at the separation plane.

([1]) The transverse inertia with respect to the separation plane must be < 60 x 10^3 m^2 kg.
(*) i.e. 70% or more of the spacecraft mass must be beyond this frequency.

4.5.4.2. Longitudinal frequencies

The fundamental frequency in the longitudinal axist must be:
≥ 31 Hz for S/C mass ≤ 4500 kg.
≥ 27 Hz for S/C mass ≥ 4500 kg.
This assumes a spacecraft hardmounted at the separation plane.

4.5.5. Dimensioning loads

During flight, low frequency dynamic and steady loads are combined to produce the quasistatic loads (QSL).

The design and dimensioning of the spacecraft primary structure must therefore allow for the most severe load combination that can be encountered at any given instant of flight. In this respect the most critical flight events are:

- at lift-off,
- during maximum dynamic pressure,
- for SRB end of flight and jettisoning,
- for main core thrust tail-off.

The corresponding flight limit loads are given in the table 4.5.5.

Acceleration (g) / Flight event	Longitudinal		Lateral	Over line load (N/mm)
Flight event	Static	Dynamic	Static + Dynamic	
Lift-off	- 1.7	± 1.5	± 2	10
Maximum dynamic pressure	- 2.7	± 0.5	± 2	14
SRB end of flight	- 4.55	± 1.45	± 1	20
Main core thrust tail-off	- 0.2	± 1.4	± 0.25	0
Max. tension case: SRB jettisoning	+ 2.5		± 0.9	0

Table 4.5.5 – Flight limit loads

***Note**: For a payload M > 5000 kg the User is requested to contact Arianespace to obtain the QSL and the angular rates to be considered.*

- The minus sign with longitudinal axis values indicates compression.
- Lateral loads may act in any direction simultaneously with longitudinal loads.
- The Quasi-Static-Loads (QSL) apply on payload C of G.
- The gravity load is included.
- These loads for a spacecraft complying with:
    - the frequency requirements of 4.5.4.1,
    - the static moments of 4.5.3.

Dimensioning must take into account safety factors, which are defined by the Spacecraft Authority (Arianespace requires a minimum value of 1.25 at ultimate stress and 1.1 at yield stress).

The secondary structures and flexible elements (e.g. solar panels, antennae and propellant tanks) must be designed to withstand the dynamic environment induced at the base of the spacecraft (as described in pare 3.1.) taking account of amplification resulting from the design of the spacecraft.

Coupled loads analysis:

The dynamic coupled load analysis (preliminary and final) carried out as part of the Mission Analysis studies (see Chapter 6.4) must be used as verification tools for the dimensioning of the spacecraft.

A simplified coupled load analysis based on a parametric spring-mass model of the spacecraft can be requested at short notice (about one month). Contact Arianespace for detailed specification.

4.5.6. Line loads

4.5.6.1. Induced by spacecraft

The maximum value of the line load, at the spacecraft/adaptor interface, induced by the spacecraft and taking into account its geometrical discontinuities (e.g. holes, stringers, ...) is allowed in local areas to be up to 10 percent over the dimensioning flux seen by the adaptor under limit loads condition.

4.5.6.2. Induced by the Launch Vehicle

Separation interface < 2624
The non uniform transmission of the thrust at the upper section interfaces (in particular the P230 thrust that applies to single forward attachment point) and the differences in the local stiffness of the launcher (stiffener / holes) induces at the spacecraft separation interface an over line load distribution which integral along the circumference is zero.
The integral of this maximum over the line load being zero, the quasi static loads are not affected.
Nevertheless, for the dimensioning and qualification of the lower part of the spacecraft has to be added uniformly to the line loads obtained at the S/C interface for the various flight events and derived from the QSL.
Its value is defined for the various load cases in the table 4.5.5.

Separation interface = 2624
The value to be considered will be provided on request.

4.6. Spacecraft compatibility tests

4.6.1. Spacecraft structural qualification and acceptance tests

The Spacecraft Authority has to prove that the spacecraft structure is capable of withstanding the Ariane flight environment based on a coupled load analysis provided by Arianespace as well as the random and acoustic environment described in chapter 3.

The spacecraft mathematical model to be provided by the User to Arianespace for carrying out the launch vehicle/spacecraft coupled load analysis has to be validated by test.

The spacecraft structural capability must be proven by adequate tests. The following classification corresponds to current practice:

1) Structural Test Model approach

- static, sine and acoustic qualification tests on structural test mode,
- sine and acoustic protoflight tests (qualification level, acceptance duration) on first flight model,
- subsequent flight models, see recurrent spacecraft.

2) Protoflight Model approach

- static qualification by heritage,
- sine and acoustic protoflight tests on first flight model,
- subsequent flight models, see recurrent spacecraft.

3) Recurrent spacecraft

- acoustic or
- sine and acoustic.

The mechanical environmental test plan for spacecraft qualification and acceptance shall be reviewed by Arianespace prior to implementation of the first test. The selected test must comply with the requirements presented from para. 4.6.1.1. to 4.6.1.6.

4.6.1.1. Static qualification tests

On the basis of the Ariane quasi-static loads as described in para. 4.5.4. the User determines the dimensioning load cases to which the spacecraft structure will be subjected. The static tests shall be carried out without rupture up to flight limit loads, multiplied by a factor > 1.25.

4.6.1.2. Sinusoïdal vibration tests

Sine	Frequency range (Hz)	Qualification levels (0-peak) (recommended)	Acceptance levels (0-peak)
Longitudinal	4-5 5-100	12.4 mm 1.25 g	9.9 mm 1 g
Lateral	2-5 5-25 25-100	9.9 mm 1 g 0.8 g	8.0 mm 0.8 g 0.6 g
Sweep rate		2 oct./min	4 oct./min

A notching procedure will be agreed on the basis of the latest dynamic coupled load analysis available. Launch vehicle forcing function discrepancies are taken into account in the CLA results. In addition, a 1.25 safety factor will be applied in order to determine the maximum allowable notching levels for protoflight or qualification tests.

4.6.1.3. Acoustic vibration Test

Octave band centre frequency (Hz)	Qualification Level (recommended)	Acceptance level (flight)	Test tolerance
	0 dB: (ref. 2×10^{-5} pascal)		
31.5 63 125 250 500 1000 2000	132* 134 139 143 138 132 128	128* 130 135 139 134 128 124	-2, +4 -1, +3 -1, +3 -1, +3 -1, +3 -1, +3 -1, +3
Overall level	146	142	-1, +3
Test duration	2 minutes	1 minute	

*** Note:** Should the test facility does not allow to reach this level, waivers can be granted for this octave band based on a precise analysis of the actual test levels. A 0.5 s mean duration analysis of the acoustic test signal must demonstrate that the acceptance level and the qualification level have been reached during a sufficient duration to cover the flight environment.

The tolerance indicated in the above table allows for standard test-equipment inaccuracy.

Fill factor: special consideration shall be given to spacecraft which fill factor, calulated as the ratio of the horizontal cross area of spacecraft maximum including its appendages solar panels and antennaes, over the fairing / SPELTRA (∅ 5000) is greater than 60 %.

Fill factor	0 to 60 %	60% to 85%	85%
Fill factor correction	0 %	Linear interpolation	100 %

100 % of fill factor correction corresponds to +4 dB at 31.5 Hz and + 2 dB at 63 Hz.

The test levels are to be measured, in the acoustic chamber, at a minimum distance of one meter from the spacecraft. User's wishing to apply a one-third octave band spectrum are requested to submit it to Arianespace for comments.

4.6.1.4. Shock qualification

The spacecraft and, in particular, the equipments located close to the separation interface, must withstand the shock specified in para. 3.1.7. Spacecraft dimensioning must take into account this specification to define equipment base environment. The demonstration of the spacecraft ability to withstand this shock can be made through a test and an analytic demonstration performed in two steps :

- a shock test characterization (generating a shock at the interface), during which interface levels and equipments base levels are measured.
  This test can be performed on the STM, PFM or on the first flight model, provided that the spacecraft structure close to the interface and the equipments locations and mountings are the same as on the flight model. This test can be performed once, and the verification performed covers the spacecraft platform as far as no structural modification alters the validity of the analysis.

- an analytic demonstration of the qualification of the equipment. This is obtained by comparing the component unit qualification levels to the equipment base levels experienced applying the interface shock specified in chapter 3.1.6 (with the addition of a qualification margin of 3 dB) and with the transfer functions defined during the shock characterization test. This demonstration could be made by using equivalent rules on other environment qualification test (i.e. random or sine).

4.6.2. Interface tests

At User's request, the following tests can be arranged, based on the provision of specific Ariane hardware.

4.6.2.1. Mechanical compatibility tests

Flight configuration test hardware can be provided for 937, 1194, 1663 and 1666 mm diameter interfaces, with associated separation systems and umbilical connectors, without cabling.

4.6.2.2. Fit-check

Ariane flight adaptors can be provided for 937, 1194, 1663 and 1666 mm diameter interfaces, with associated separation systems and umbilical connectors, without cabling.

4.6.2.3. Shock test

- Flight configuration test hardware can be provided for 937, 1194, 1663 and 1666 mm diameter interfaces with the associated separation systems and consumable items.

  It is recommended that this test be performed in conjunction with the mechanical compatibility check.

- A shock Generation Unit (SHOGUN), generating a shock more representative to the one that occurs in flight, can be provided. This system allows to reduce the uncertainties margins taken into consideration for the shock compatibility analytic demonstration.

4.6.2.4. Acoustic test

Flight configuration test hardware can be provided for 937, 1194, 1663 and 1666 mm diameter interface for acoustic test, up to flight levels.

Launch operations — Chapter 5

5.1. General

Ariane 5 launch operations are carried out by Arianespace from Ariane Launch Site number 3 (ELA-3), located at the Guiana Space Centre (CSG), in French Guiana.

General information concerning French Guiana is given in Annex 1.

Buildings and associated facilities available for spacecraft preparation are described in the Payload Preparation Complex (EPCU) Manual (CD-ROM).

Operations in the EPCU are carried out under the responsibility of Arianespace with the support of CSG teams.

This chapter describes the typical spacecraft operations carried out in Guiana.

5.2. Launch campaign organization

During the operations at CSG, the User interfaces with the Mission Director (CM) representing the entire Launch Authority (Arianespace and CSG). The Mission Manager, the User's contact in the previous phases, maintains his responsibility for all the non-operational activities.

The launch campaign organization is presented here below.

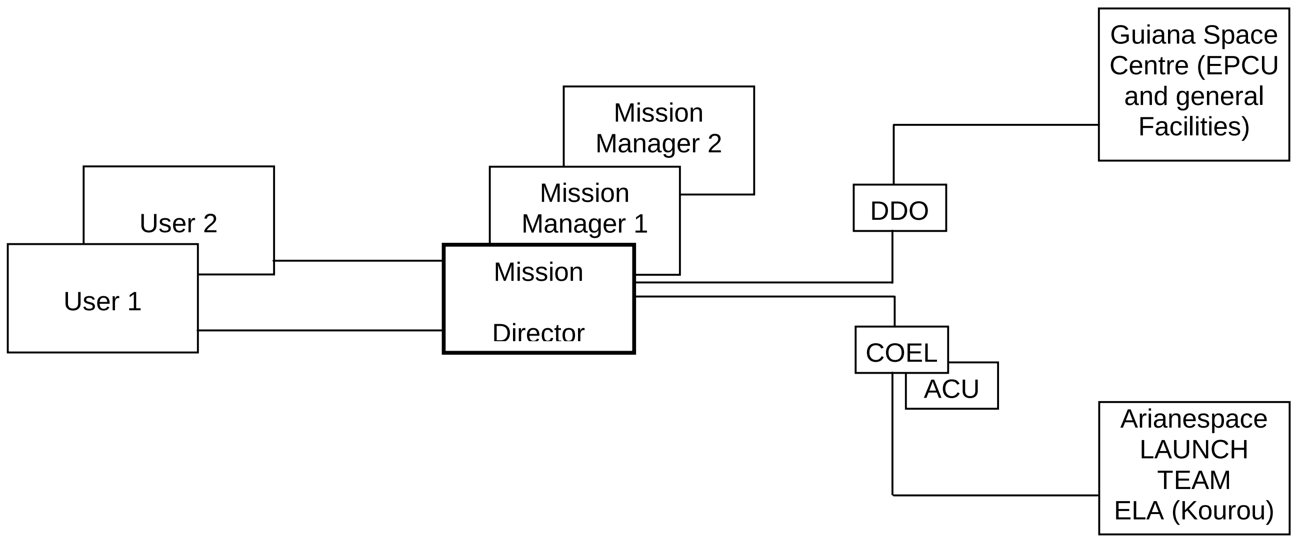


Fig. 5.2.a. – Launch campaign simplified organization chart

5.3. Operational safety constraints

The Safety Regulations define the rules applicable to all operations involving the use of hazardous systems or products, and the constraints to be observed in the definition and performance of launch vehicle and spacecraft operations.

5.3.1. Limits of liability

The Spacecraft Authority is responsible for all spacecraft and associated ground equipment operations. When potential sources of danger are handled by CSG personnel, operations remain under the responsibility of the Spacecraft Authority.

Safety of the User's team comes under the general heading of safety of personnel working at the CSG, governed by CSG Safety Regulations.

Any activity involving a potential source of danger is to be reported to CSG, which in return takes all steps necessary to provide and operate adequate collective protection equipment, and to activate the emergency facilities.

Each member of the spacecraft team must comply with the safety rules regarding personal protection equipment This is checked by CSG, which gives the relevant clearance to start operations.

On request from the User, CSG can provide specific items of protection for members of the spacecraft team. Upon arrival at CSG, spacecraft personnel will be given safety courses. In addition, training courses on the operations of range facilities will be given to appointed operators.

All payload activities on the launch site are carried out in accordance with instructions given in the related procedures prepared by the User and by the Ariane Authority where combined operations are concerned. These procedures are approved by the CSG Ground Safety Department, and covered by formal authorizations.

5.3.2. Constraints

5.3.2.1. Ground Constraints

The launch vehicle and the payload (composed of one or more spacecraft) represent hazards for one another.

Restrictions on payload operations and access may therefore be imposed during periods of combined operations due to safety constraints.

Coordination is exercised by the Ariane Authority.

5.3.2.2. Flight constraints

- *During the powered phase* of the launch vehicle and up to separation of the payload(s), no telecommand signal can be sent to the payload(s), or generated by a spacecraft onboard system (sequencer, computer, etc...). During this powered phase a waiver can be studied to make use of commands defined in paragraph 4.4 providing that the radio electrical environment is not affected.

- *After the powered phase and before the spacecraft separation,* the commands defined in paragraph 4.4 can be provided to the spacecraft.

- *To command operations on the payload after separation* from the launch vehicle, microswitches or telecommand systems (after 20 s) can be used. Initiation of operations on the payload after separation from the launch vehicle, by a payload on-board system programed before lift-off, must be inhibited until physical separation.

	▼ H0 – 1h30 mn	▼ Upper Stage burn-out	▼ Separation	▼ Separation + 20 s
Telecommand	NO	NO	NO	YES
S/C Sequencer	NO	NO	YES	YES
L/V orders	NO * WAIVER POSSIBLE	YES	NO	NO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5.4. Spacecraft field operations and planning

Definition of operations:

Operations at the CSG are carried out in three phases:

- Phase 1: spacecraft preparation and checkout (if needed).
- Phase 2: spacecraft hazardous operations.

  Both phases are named POI (InterleaVed Operations Plan).

- Phase 3: combined operations for spacecraft SPELTRA/Fairing encapsulation (or SYLDA 5) and launch site (this phase is named POC Combined Operations Plan).

Phase 1 operations take place in S1 buildings at the CSG Technical Centre or in S3 buildings for the non hazardous operations.

Phase 2 operations are carried out in S2, S3 and S4 buildings, located in the Ariane Launch Complex.

Phase 3 operations take place in S3 Buildings and in the Final Assembly Building (BAF).

Figures 5.4.a, 5.4.b and 5.4.c show the location of these facilities.

The spacecraft campaign duration, from equipment arrival in French Guiana until, and including, departure from Guiana, should not exceed 49 calendar days (45 days before launch, day of launch and three days after launch).

A typical spacecraft operations time schedule is shown in figure 5.4.d. It is based on a daily two shifts, five days a week basis.

A typical operations flow diagram is shown in figure 5.4.e. as a guide line.

5.4.1. Phase 1: Spacecraft preparation and checkout (if needed)

Details of port and airport facilities are given in Annex 1 and also described in the EPCU CD-ROM. Unloading is carried out by the port or airport authorities under the Users responsibility in coordination with Arianespace. Equipment should be packed on pallets or in containers and protected against rain and condensation.

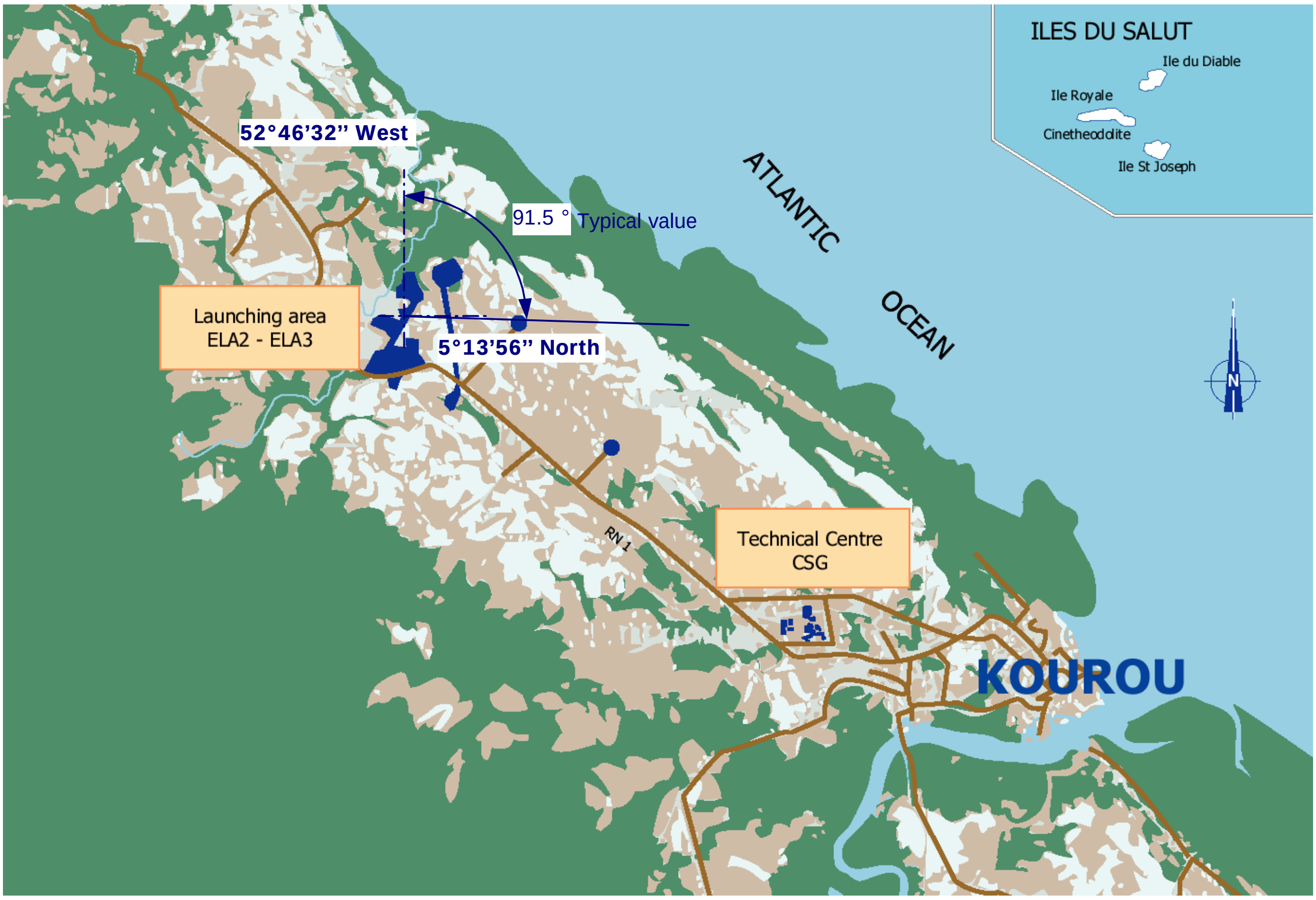


Figure 5.4.a – Guiana Space Centre (CSG)

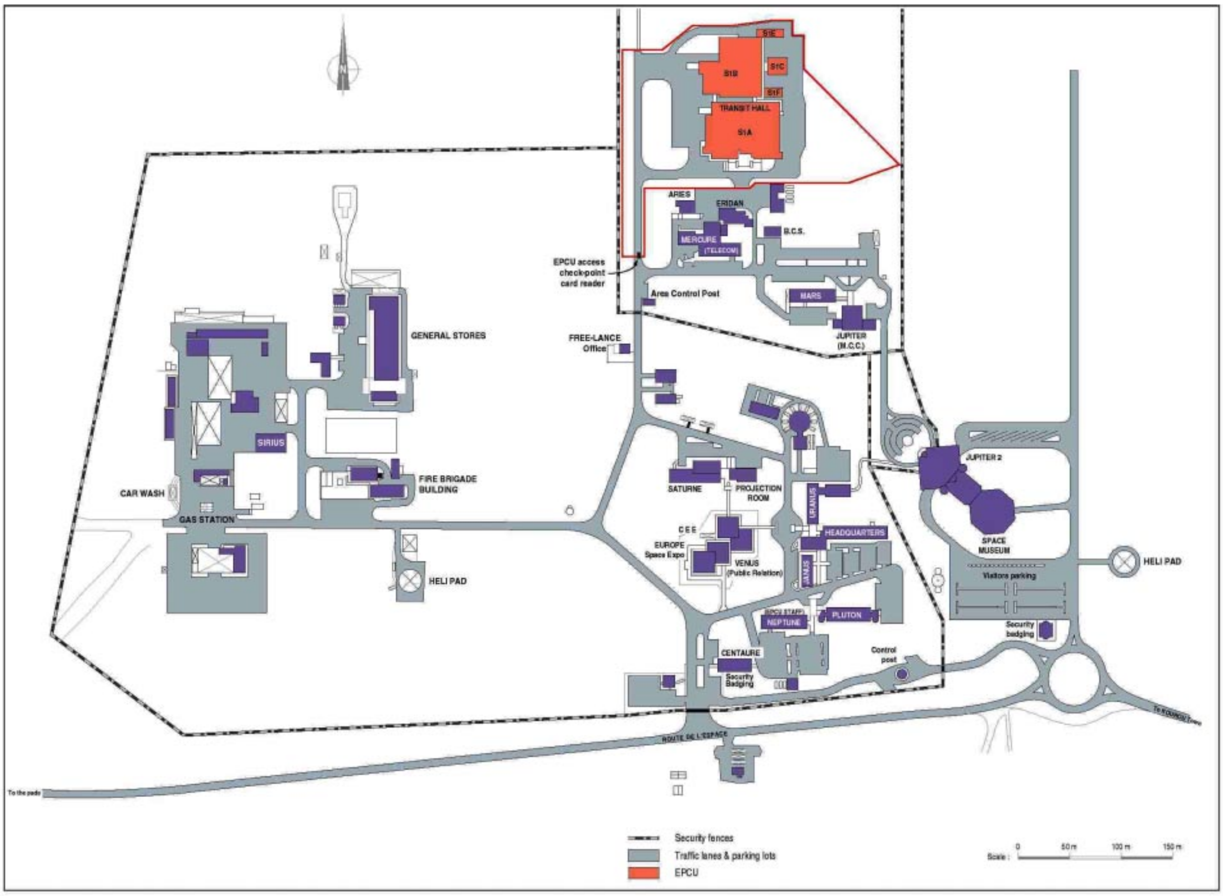
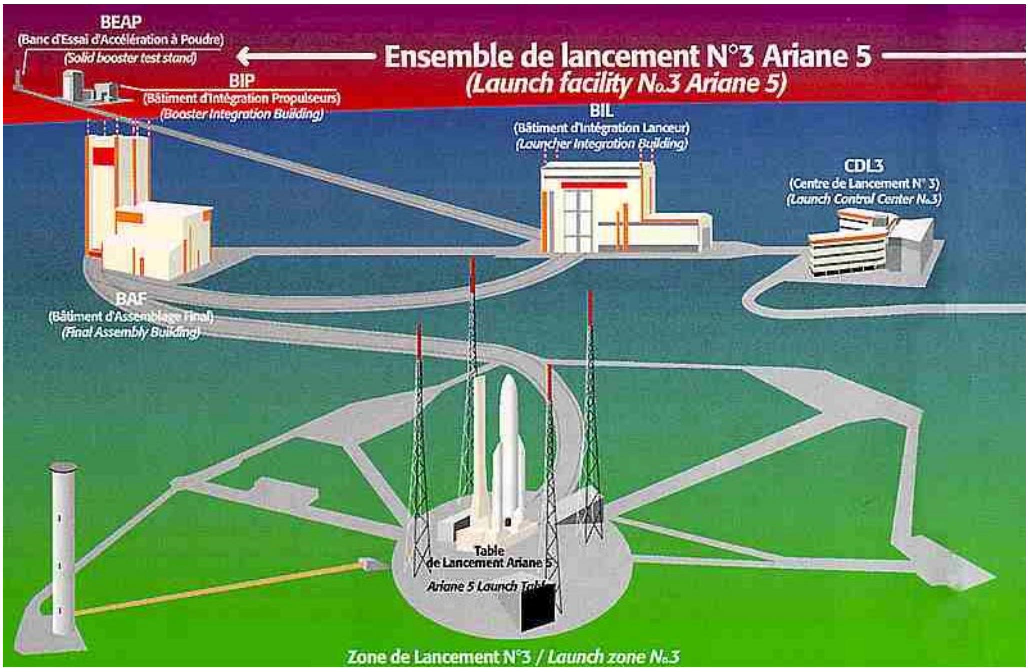


Figure 5.4.b – CSG Technical Centre



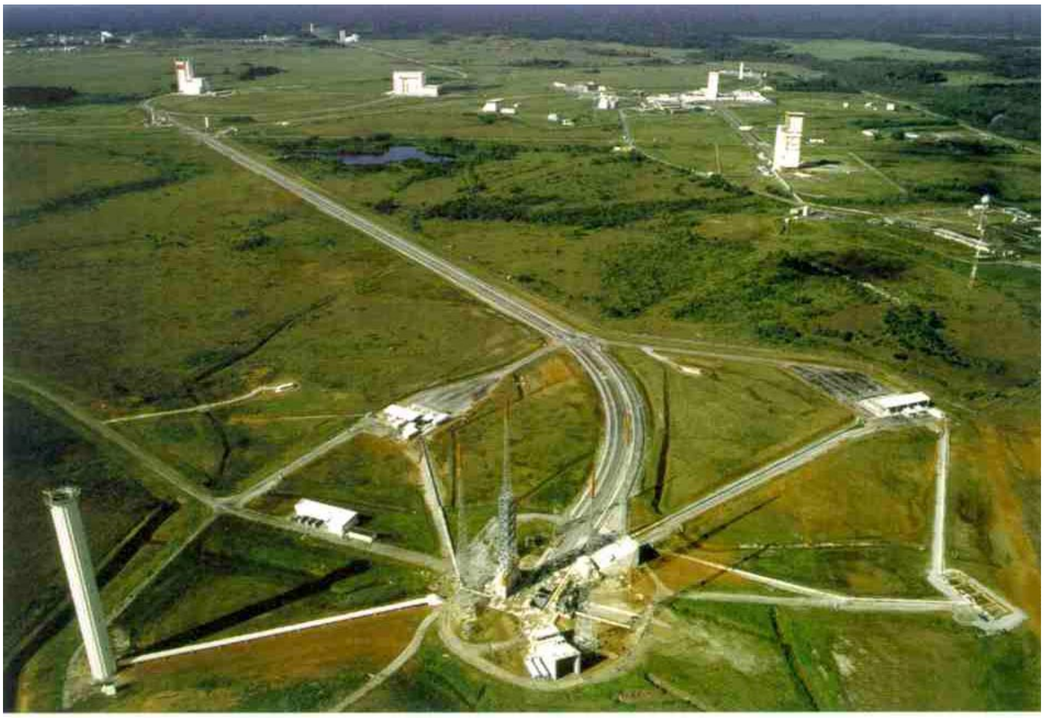


Figure 5.4.c – Ariane Launch Complex no. 3 (ELA-3)

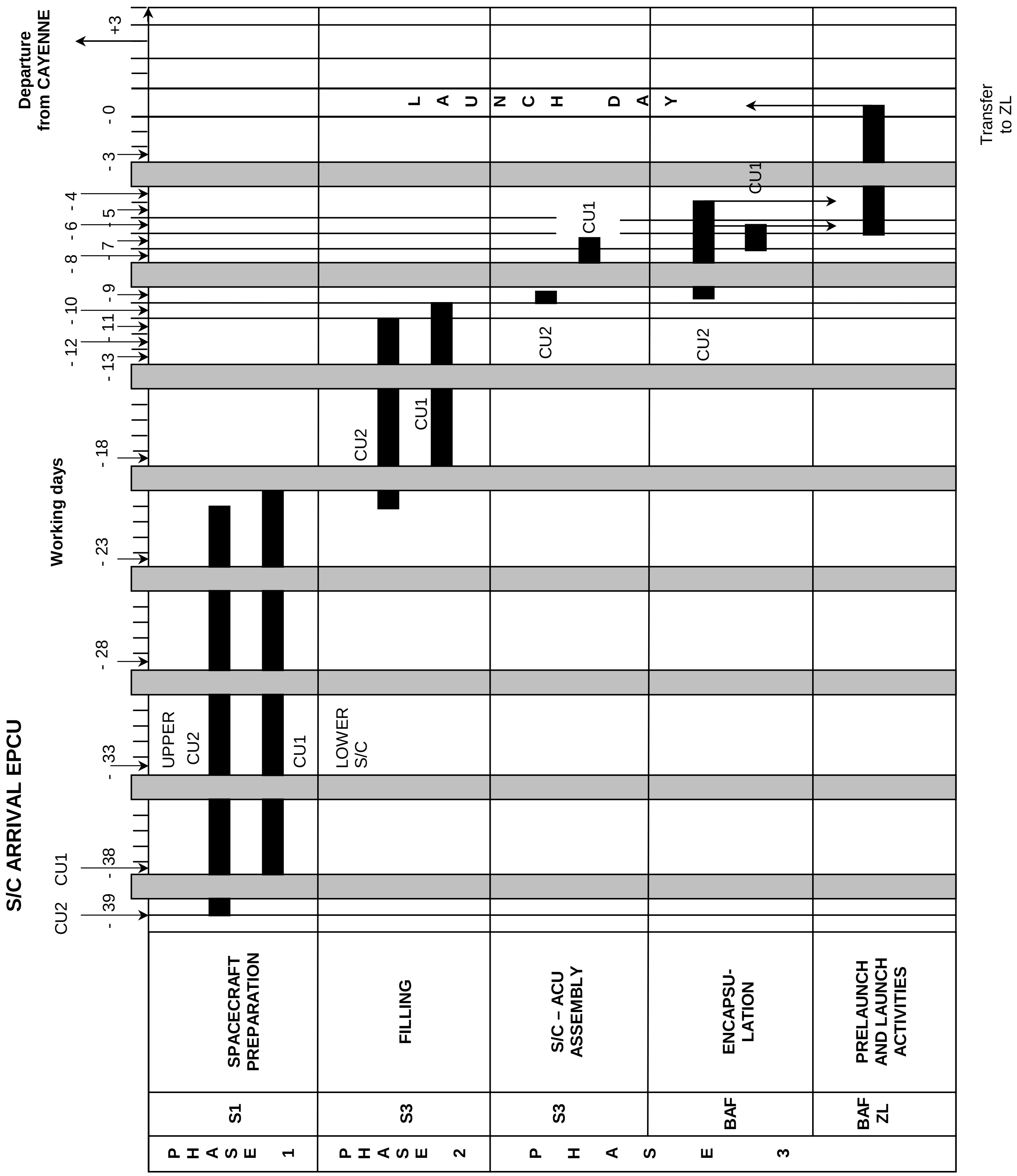


Figure 5.4.d – Typical Spacecraft Operations Time Schedule (example)
Dual Launch

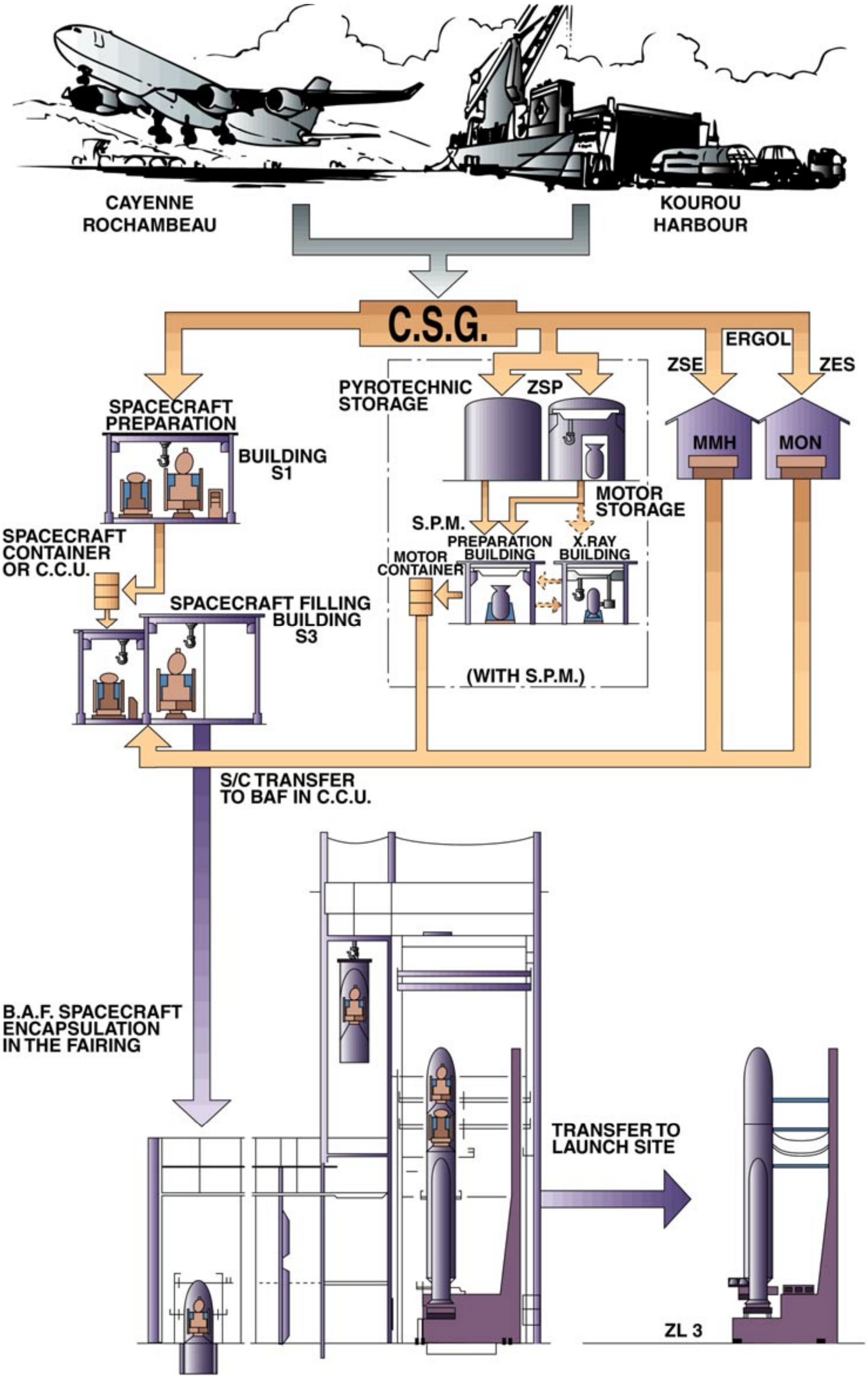


Figure 5.4.e – Typical Operations Flow Diagram

Cayenne port and airport are linked to the CSG by road. Transport within French Guiana is coordinated by the Ariane Authority and usually carried out by CSG (minimum speed 50 km/h).

On arrival at the CSG Technical Centre, the spacecraft in its container, together with associated ground equipment, are unloaded in the S1 area Transit Hall. However the spacecraft in its container could be directly transported to the S3 building.

In the Spacecraft Operations Plan (POS), the User defines the way his equipment should be arranged and laid out in CSG buildings.

The Ariane Authority is in charge of equipment unloading and dispatching operations.

Solid motors in their containers are stored in SPM buildings of the ZSP. Pyrotechnic systems and any other hazardous systems of the same class are stored in the pyrotechnic devices buildings of the ZSP. Hazardous fluids are stored in the propellant-support zone of the Ariane launch site. Radioactive sources are normally stored in S1 building unless otherwise specified by CSG Safety.

The User states which equipment has to be stored in an air-conditioned environment. Other equipment will be stored under open shed conditions.

Spacecraft check-out equipment is accommodated in S1 building and connected to the CSG power and operational networks with CSG support.

The spacecraft is removed from its container and deployed in the S1 clean room. This also applies for flight spare equipment.

The spacecraft is assembled and undergoes functional checks (non-hazardous mechanical and electrical tests). Category B pyrotechnic items only may be integrated into the spacecraft in S1 building.

Appropriate operations interfacing with L/V operations are carried out during this phase (such as: mechanical fit check, electrical check out of flight adaptor and ground lines, etc ...).

When all checks have been completed, the spacecraft is placed in its own container or in the Payload Container (CCU) for transport to the Ariane Launch Complex.

A typical flow diagram of phase 1 operations is shown in figure 5.4.1.a.

5.4.2. Phase 2: Spacecraft hazardous operations

Hazardous operations are carried out in S2 and S4 buildings for solid propellant motors (SPMs) and S3 building for spacecraft. Liquid propellant motors are prepared in a filling hall in S3 building. Validation of spacecraft ground equipment such as filling and pressurization systems are carried out by the Spacecraft Authority in S3 building before arrival of the spacecraft. The SPM is assembled to the spacecraft in the same hall of S3 building.

The spacecraft operations performed in S3A/S3B buildings will be monitored from S3C building CDL3 or direclty from S1. The associated Electrical Ground Support Equipment used during hazardous operations may be located in and operated from the control rooms of S3C building CDL3 or directly operated from S1.

Some phase 2 operations can be undertaken in parallel with phase 1 operations.

A typical flow diagram of phase 2 operations is shown in figure 5.4.2.a.

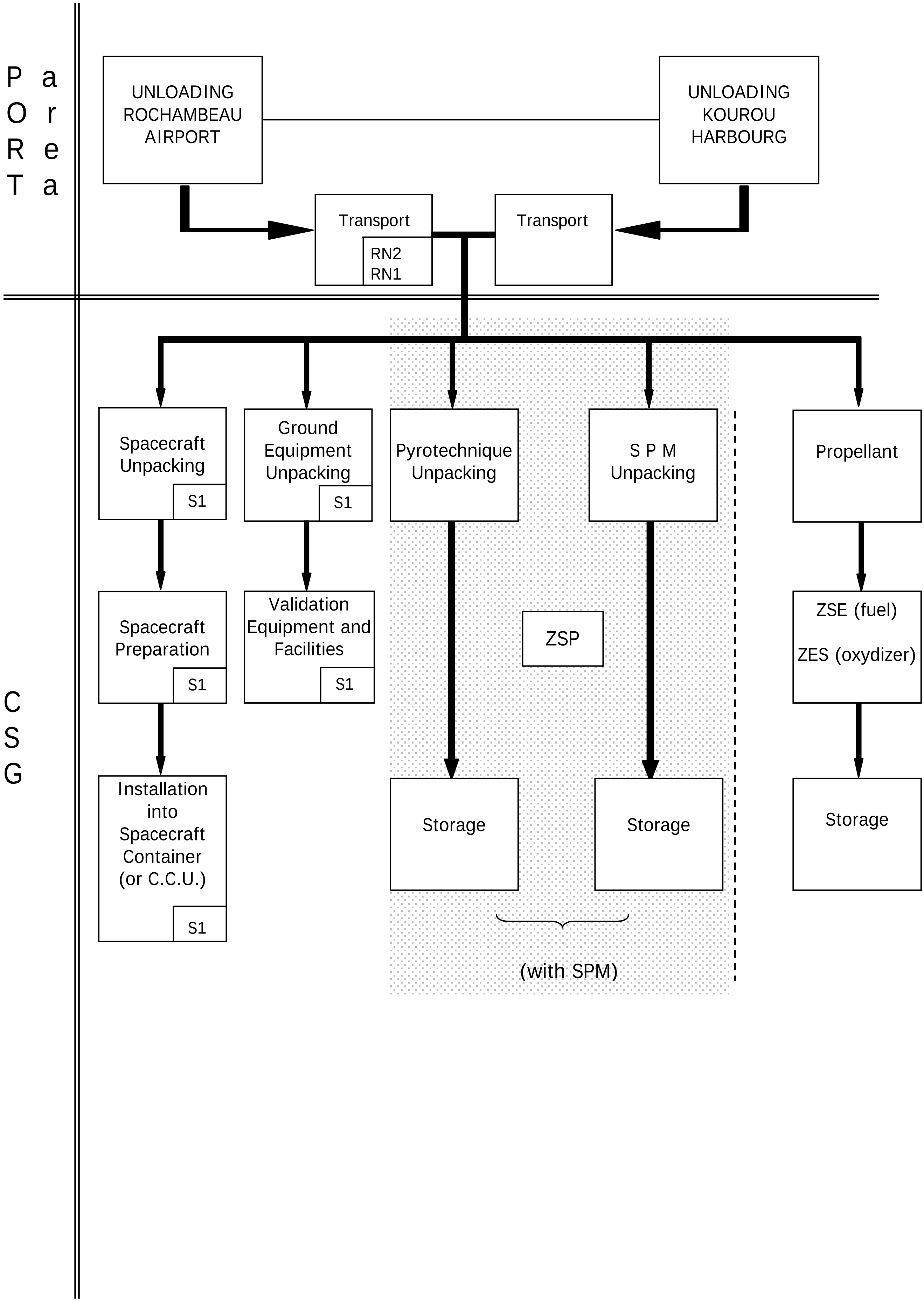


Figure 5.4.1.a – Operations Phase 1: Typical Flow Diagram

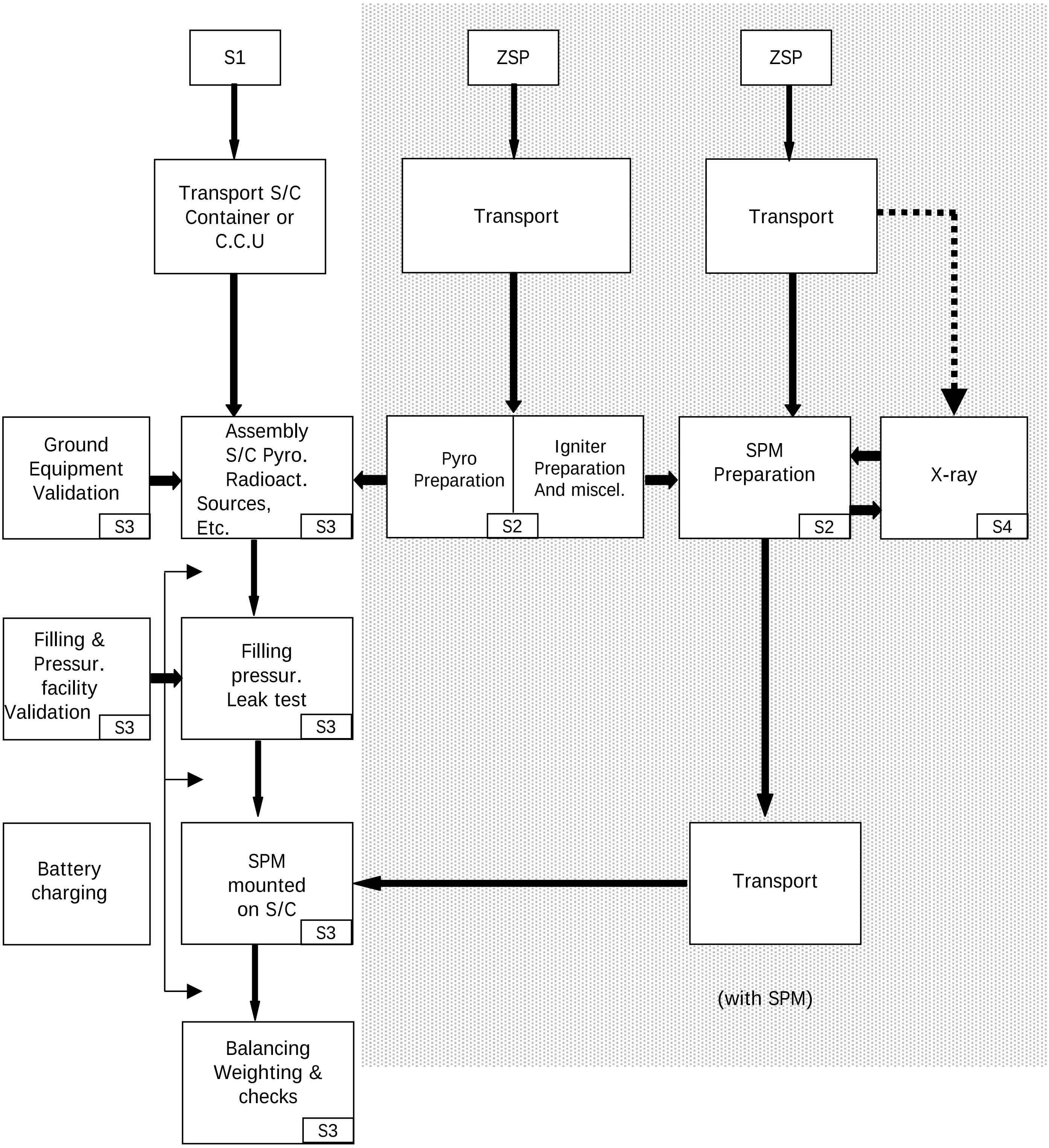


Figure 5.4.2.a – Operations Phase 2: Typical Flow Diagram

5.4.2.1. Pyrotechnic preparation

Checks of pyrotechnic systems required before integration into the spacecraft are carried out in S2 building.

5.4.2.2. Preparation of SPMs

Removal from store and transport to S2.
SPMs stored in the SPM building of the ZSP, can undergo X-ray examination in S4 building, before or after transport in their containers, to S2 building. SPM X-ray checks are carried out by the User with Ariane technical support.

Preparation and checks.
The SPM is assembled and checked. The pyrotechnic motor ignition system is transported from the pyrotechnic devices building of the ZSP to S2 building for check prior to assembly into the motor.

Packing and transport to S3.
When fitted with its igniter, the SPM is placed in its container and transported to the access airlock of S3 building.

Preparation for assembly.
The SPM, with its igniter fitted, is removed from its container, and placed in one of the S3 Filling and Assembly Halls.

5.4.2.3. Operations on spacecraft

5.4.2.3.1. Transport and installation in S3

The spacecraft in its container or in a CCU (see EPCU manual) is transported from building S1 to the access air lock of building S3 no earlier than 20 working days before launch. It is then removed from the container, and placed in one of the filling and assembly halls. If S1 building is not used, the spacecraft in its container is transported directly from airport or habour to access dock of S3 building, not earlier than 20 working days before launch.
The pressure and temperature monitoring equipment are located in the SC3 or S3A/B laboratories.
The spacecraft Check-Out Terminal Equipment (COTE) is linked to the OCOE by data lines to allow remote control (figure 5.4.3.11.b).

Depending upon COTE necessity to charge batteries one or two COTE has to be supplied by the customer. This analysis will be done on a case by case basis.
The COTE main functions will be:

- S/C ground power supply.
- Hazardous circuits activation (AKM...).
- S/C critical status recording during roll-out (see para 5.4.3.9.).
  It will be connected directly to the Ground Umbilical lines of the launch Mast (Figure 5.4.3.11.c).

5.4.2.3.2. Fluid filling and pressurization

The spacecraft tanks are filled and pressurized to flight level.

When necessary, depressurization, purging and flushing operations may be carried out in a S3 hall.

Propellant fluid filling and pressurization operations are carried out by the User. The pressure and temperature monitoring equipment is located in S3C control room.

Spacecraft batteries may be trickle charged in S3 building, except during dynamic hazardous operations.

Ground lines (continuity, insulation, etc ...) between S3 Buildings, hardlines and radio links between S3 and S1 buildings have been checked previously and certified by Arianespace (and witnessed by the Spacecraft Authority if so requested).

5.4.2.3.3. Assembly of pyrotechnics, radioactive sources and miscellaneous items

The assembly of various hazardous items (category A pyrotechnic devices, SPM, radioactive sources, etc...) into spacecraft is carried out in S3 building.

5.4.2.4. Final spacecraft assembly

5.4.2.4.1. Balancing and weighing

If required by the User, a balancing operation may be carried out on the spacecraft, with or without SPM and fluids, under the responsibility of the User, with CSG technical support. A weighing device is available in each Filling and Assembly Hall (the balancing machine is located in S3A).

5.4.2.4.2. Checks and inspection

Electrical, mechanical and arming checks are carried out in the S3 building assembly hall. A spacecraft final inspection is made before the beginning of the Combined Operations Plan (P.O.C.) (refer to chapter 6).

5.4.3. Phase 3: Combined operations for Spacecraft / SPELTRA-SYLDA 5-Fairing encapsulation and launch site

5.4.3.1. Typical flow diagram of phase 3 operations

See figure 5.4.3.1.a

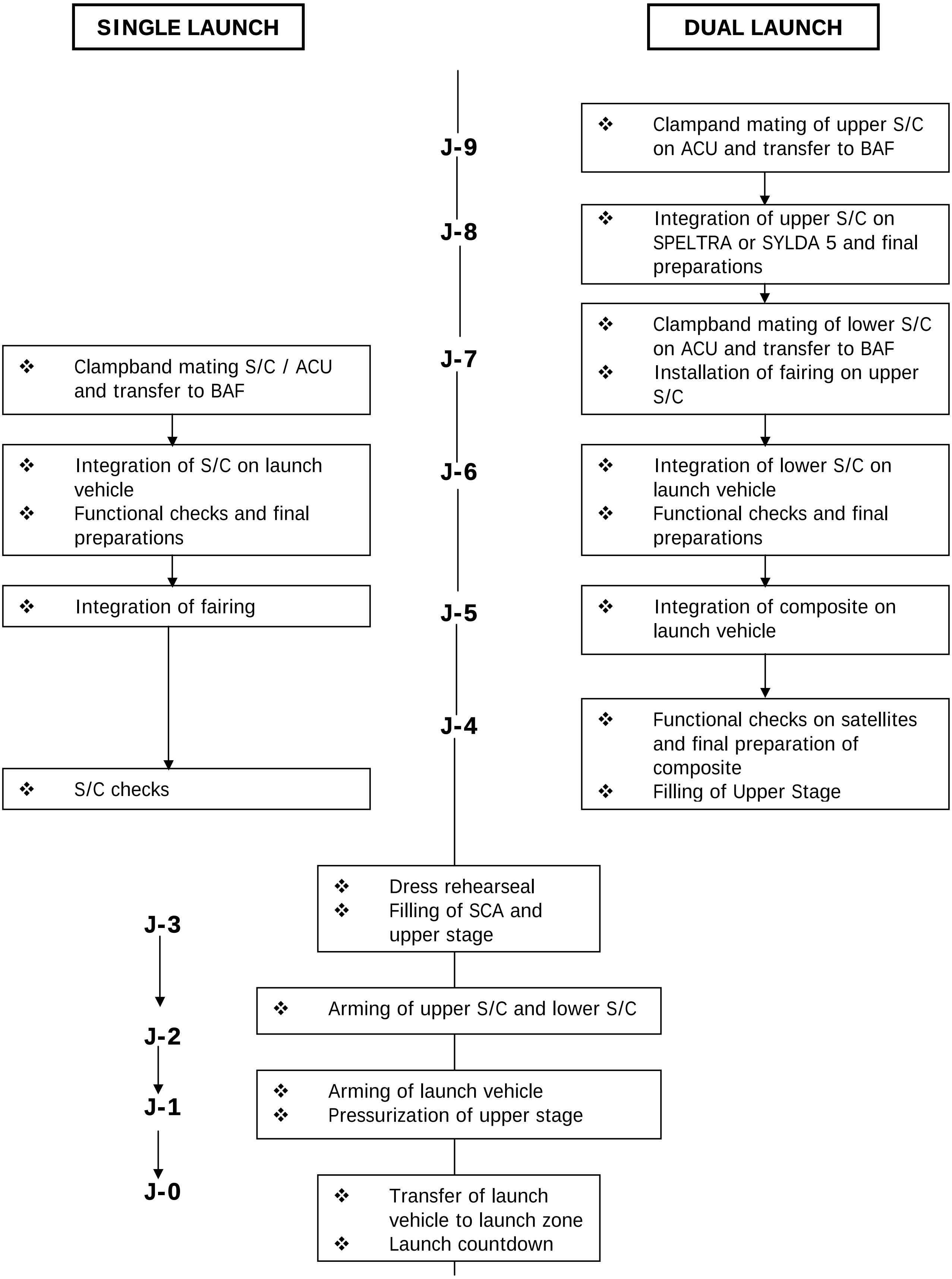


Figure 5.4.3.1.a Operations Phase 3: Typical Flow Diagram

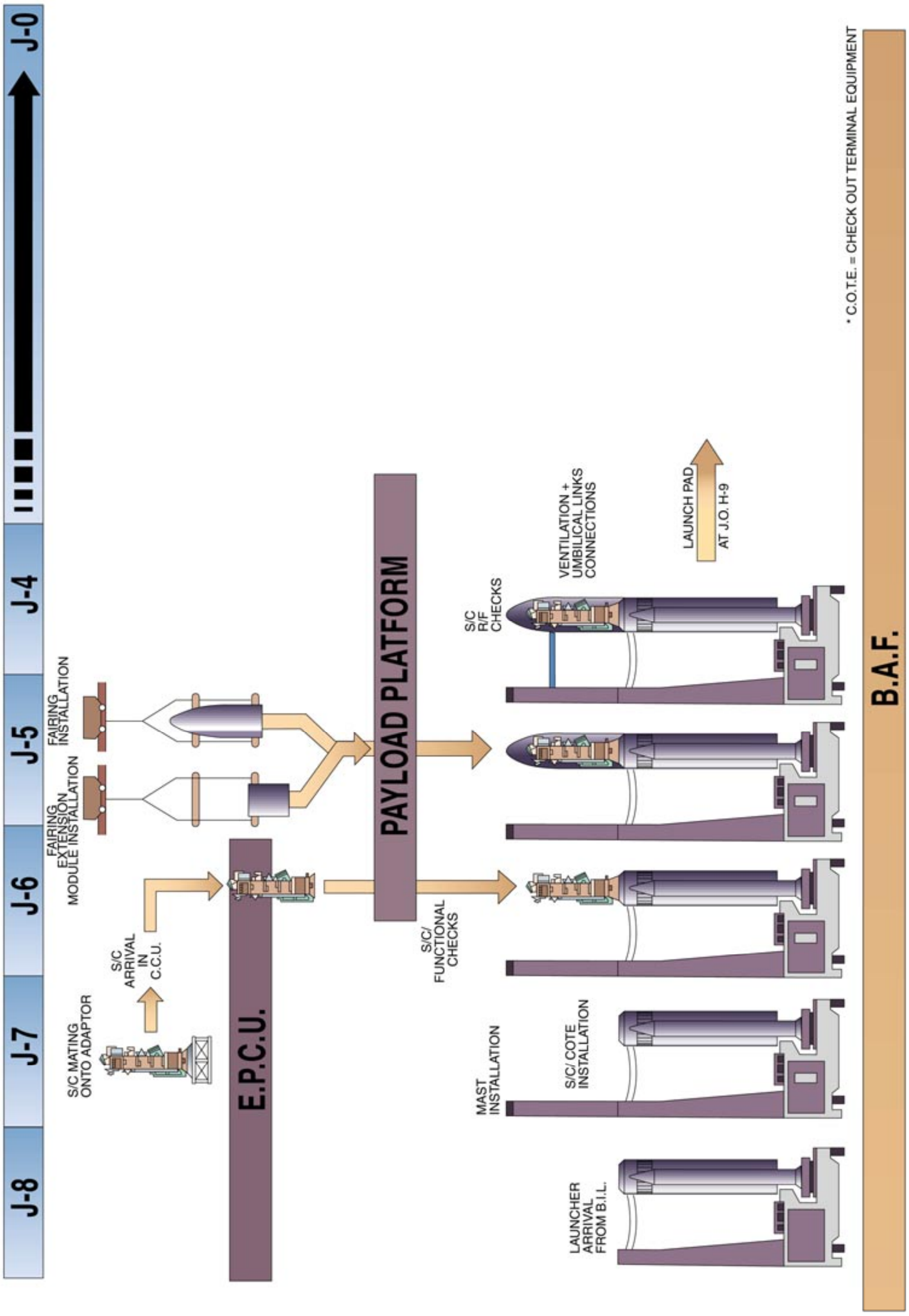


Figure 5.4.3.1.b Typical Single Launch Encapsulation Sequence

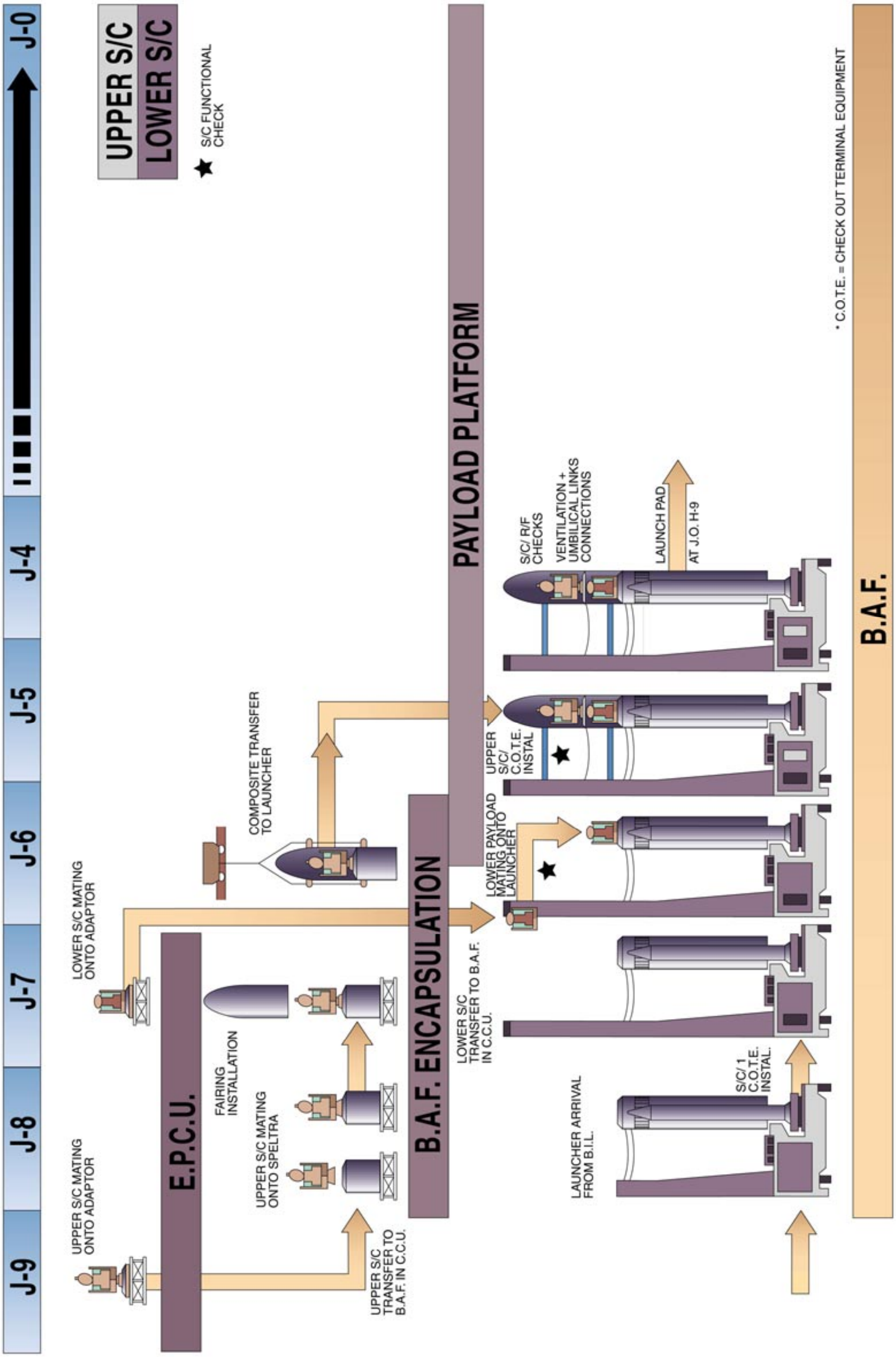


Figure 5.4.3.1.c – Typical dual Launch Encapsulation Sequence with SPELTRA

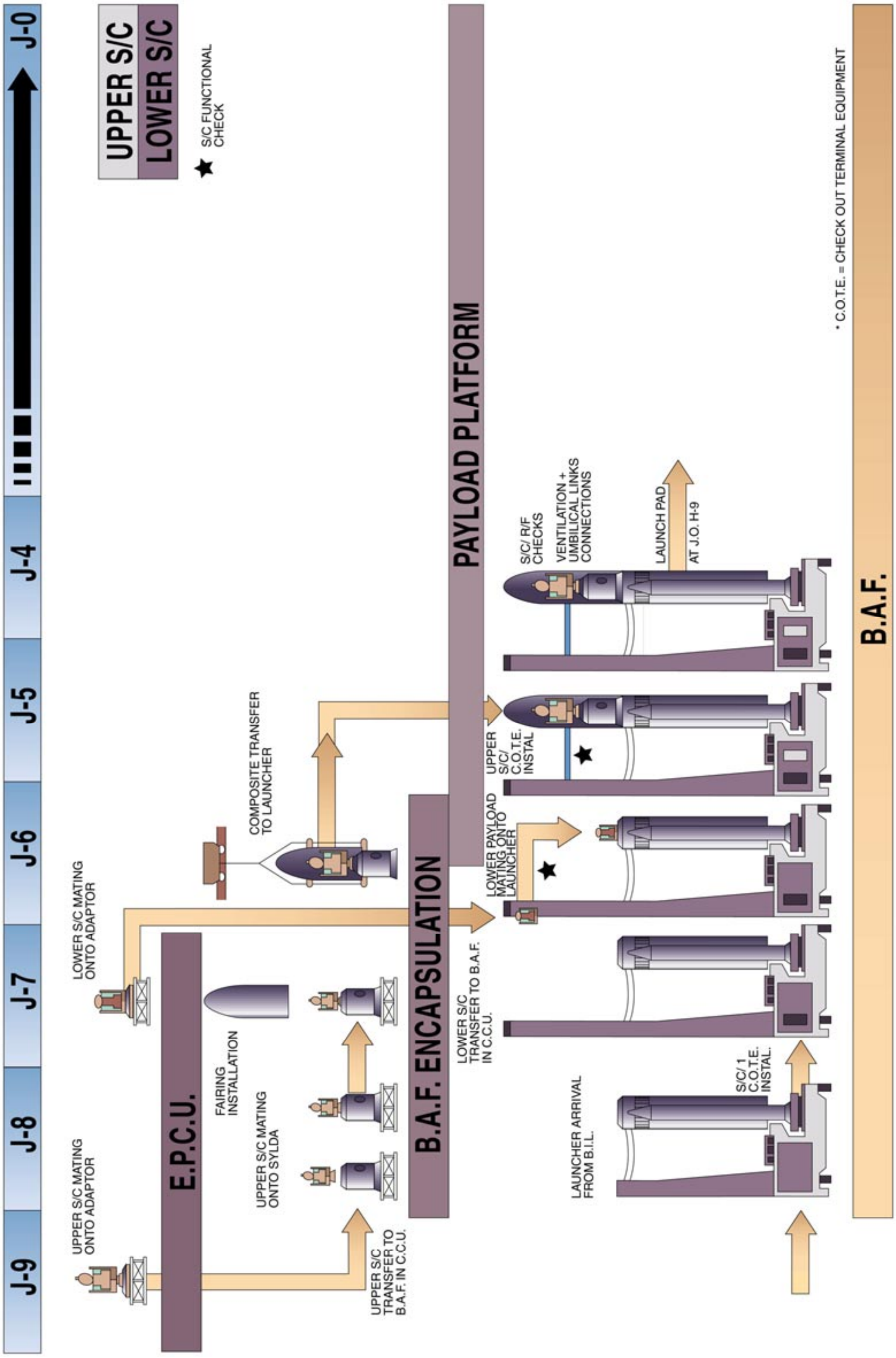


Figure 5.4.3.1.d – Typical Dual Launch Encapsulation Sequence with SYLDA 5

5.4.3.2. Spacecraft and adaptor assembly in S3 building

After filling and final preparation, the spacecraft is mated to its adaptor.

5.4.3.3. Transport of spacecraft and installation in BAF

Arianespace is responsible for transporting the S/C in one of the CCU's from S3 building to the BAF building.

The spacecraft Check-Out Terminal Equipment (COTE) is transported and installed in the BAF building. After payload encapsulation and mating to the launch vehicle the COTE is installed in the Launch Table until the launch. The payload dedicated room in the launch table has the following main features:

- 5 slots for 19" antisismic racks are available for each customer.
- COTE installation by vertical hoisting through a L= 1 m , l=0.8 m access opening in the floor (max weight 800 kg).
- Personal access through a 1730 x 1000 mm door.
- Air conditionned environment.

Details of COTE installation and interfaces can be obtained from Arianespace.
The equipments to be installed in the COTE are to be qualified either in acoustic or random wrt the following levels:

- Acoustic: (Time duration: 1 min.)

Octave bands	31.5	63	125	120	500	1000	2000	Overall
Level (db)	133	132	128	126	123	122	118	137

- Random (Time duration: 1 min.)

Bandwidth	Overall level (g eff)	PSD	Time duration
20-2000	12	0.0727	1 min on 3 axes

Umbilical lines at BAF/Launch vehicle, data/modem lines and RF links between CDL 3, BAF and S1 buildings have been checked previously.

5.4.3.4. Encapsulation Phase

The encapsulation phase is carried out by Arianespace, following the procedure presented below, in the Final Assembly Building (BAF).
Single spacecraft encapsulation: see fig 5.4.3.1.b.

Dual spacecraft encapsulation: see fig 5.4.3.1.c and 5.4.3.1.d.

Each S/C with adaptor is handled with its own handling equipment. For this reason S/C and S/C handling equipment must be capable of accepting an additional mass of 400 kg.

5.4.3.4.1. Typical SINGLE S/C encapsulatIon sequence

See fig 5.4.3.1.b.
Using the S/C handling equipment, the S/C with its adaptor is hoisted into the PFCU level and mated to the L/V. Finally the S/C is encapsulated in the Fairing.
After the payload is mated and encapsulated onto Ariane, umbilical and electrical umbilicals plugs are connected. Ventilation is provided through the pneumatic umbilicals and the S/C linked to the COTE by the connection of the electrical umbilical plug.

This is an Arianespace responsibility.

5.4.3.4.2. Typical DUAL S/C encapsulatIon sequence

See fig 5.4.3.1.c and 5.4.3.1.d.
The upper S/C, with its adaptor placed onto SPELTRA or SYLDA5, is encapsulated in the Fairing while the lower S/C with its adaptor, using the S/C handling equipment, is hoisted onto the PFCU level and mated to the L/V. Finally the inner S/C is covered by the encapsulated upper S/C. After the payload is mated and encapsulated onto Ariane, umbilical and electrical umbilicals plugs are connected. Ventilation is provided through the pneumatic umbilicals and each S/C linked to its COTE by the connection of the electrical umbilical plug.

This is an Arianespace responsibility.

5.4.3.5. Preparation and checkout of the payload mated to the launch vehicle

A functional check of each spacecraft is carried out in accordance with the combined activities time-schedule, together with certain routine operations (leak test, battery charging, visual inspection).

Before arming operations, a combined launcher/payload stray voltage test may be performed depending on EMC analysis; this implies both launch vehicle and payload radio systems to be activated.

Spacecraft activities have to allow for launch vehicle accessibility and radio-silence constraints.

Arming and disarming checks of hazardous circuits are carried out by the User after clearance by the COEL with Safety Officer's agreement.

5.4.3.6. Launch rehearsal

A launch rehearsal is held at J-3 into the BAF. This rehearsal implies the activation of all electrical and mechanical facilities involved in an Ariane launch together with the spacecraft ground network(s), in order to validate all the interfaces. The H0 instant is usually fixed, but can be defined with the customer on a case by case agreement.

5.4.3.7. Checkout and preparation before launch countdown

The spacecraft can be checked out via cable and/or radio links, at authorized times.

At J-2 the sequence of arming operations is the following:

- Fitting of the spacecraft flight plugs (the spacecraft must be inert or in standby mode).

- Closure of the spacecraft access door(s) on the fairing and the SPELTRA. No more access to the spacecraft until launch.

On J-1:

- Arming phase 1 for the launch vehicle (fitting and connection of the launch vehicle pyrotechnic devices). During this operation, access to the spacecraft is prohibited and radio-silence is required.

<u>Note</u>:
An « inert » spacecraft has no active sub-system.
A spacecraft « on stand-by » is defined as
presenting a steady state (no mechanical or electrical change of state), with no radio transmission. Batteries charging is admissible, and radio receivers may be permanently switched on. These conditions are discussed at the time of the safety submissions and finalized in the Combined Operations Plan (POC).

5.4.3.8. L/V storable propellants filling operations

These operations consist in fîlling the upper stage and SCA; this part is independent of the final countdown sequence. These operations are performed at J-4 and J- 3. Batteries may be charged and passive monitoring may be performed through umbilical lines during the upper stage filling and during the SCA filling, upon agreement through safety submission, and on a case by case basis.

5.4.3.9. Transfer of L/V from BAF to ZL -JO

<u>H0-11h</u>: preparation of the BAF and L/V for the transfer to the ZL.
<u>H0-9h</u>: launch table electrical and fluids plug disconnection
<u>H0-8h30</u>: Departure from BAF- Roll out
<u>H0-7h30</u>: Connection of launch table electrical and fluids umbilicals
<u>H0-6h</u>: Start of countdown

<u>Note</u>:
During the tranfer, the S/C can be monitored and battery charging is possible.

5.4.3.10. Check-out and preparation before launch countdown

The spacecraft can be checked out via cables and/or RF links, at authorized times.
The spacecraft/launch pad electrical interfaces are shown in figure 5.4.3.11.e.

During this sequence, the main constraints applying to the spacecraft are the following:

- Spacecraft RF and functional tests:
  RF and/or functional tests (health check) may be performed at any time up to Ho-TBD.
  This slot must be shared by the satellites as shown on figure 5.4.3.11.a.

- SPM arming (if necessary)
  SPM arming phase starts at H0-1h00

- Spacecraft RF flight configuration
  The final RF flight configuration set up must be completed before H0-TBD and remains unchanged until 20 s after separation.

- Spacecraft internal power switch on
  The external/internal power switch on phase is performed such that the spacecraft must be ready for launch before the beginning of the L/V automatic sequence.

- L/V automatic sequence
  Initiated at H0-7min.

- Countdown hold
  In case of stop action during the final sequence, the spacecraft can be reconfigured in external power supply, and the count down clock is set back to H0-7min.

- Spacecraft stop action
  The spacecraft stop action is activated until H0-9 seconds.

5.4.3.11. Launch count-down Phase

The final count-down sequence starts after the launcher transfer from the BAF to the ZL at about H0-6 hours.

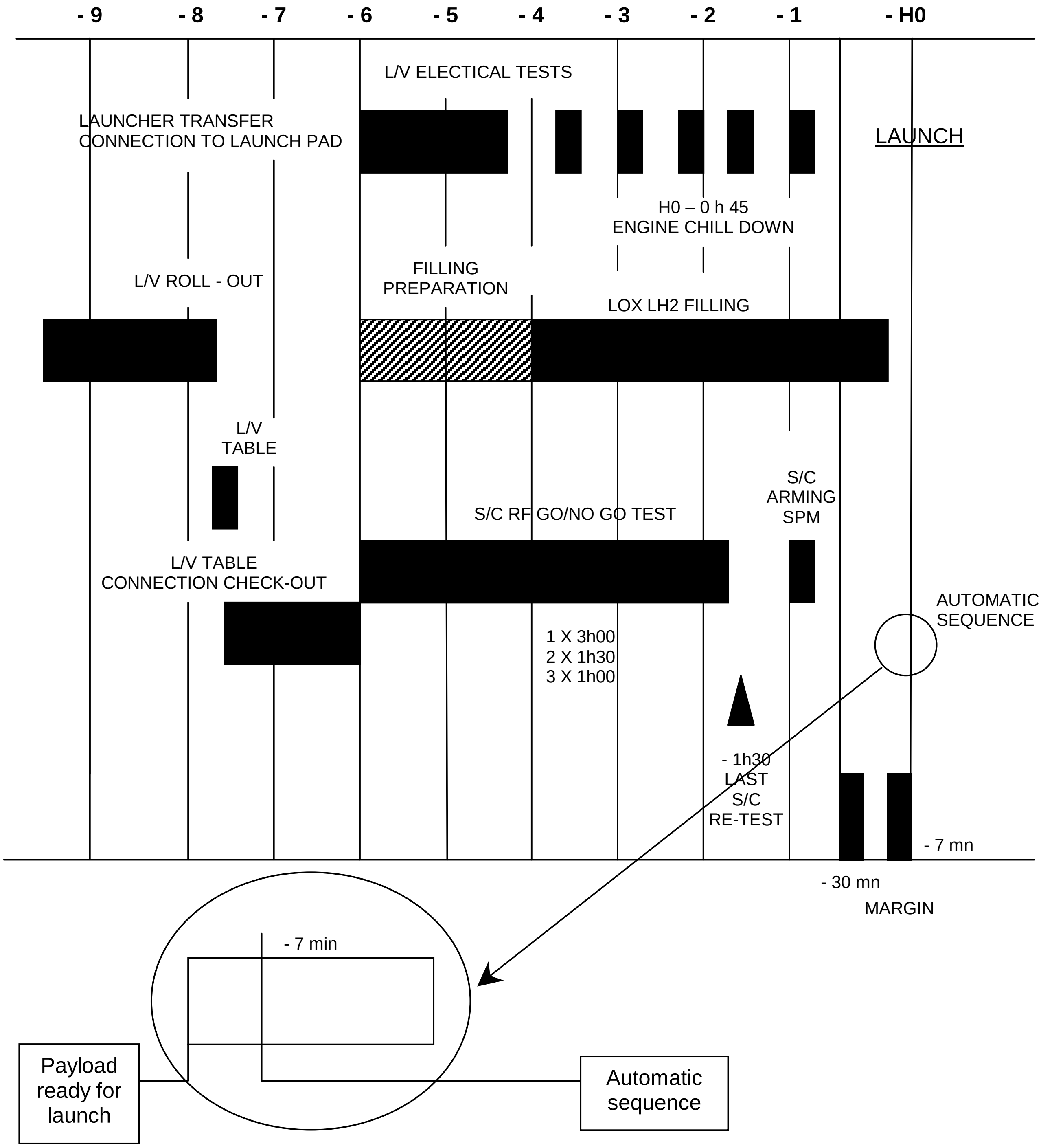


Figure 5.4.3.11.a Final Count-Down Phase

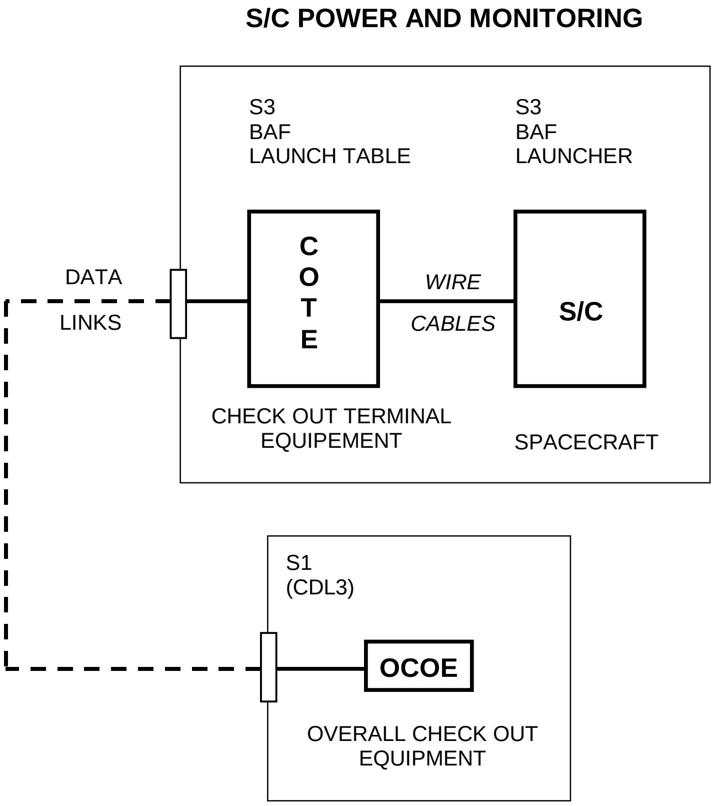


Figure 5.4.3.11.b - General Check-out Configuration Synoptic

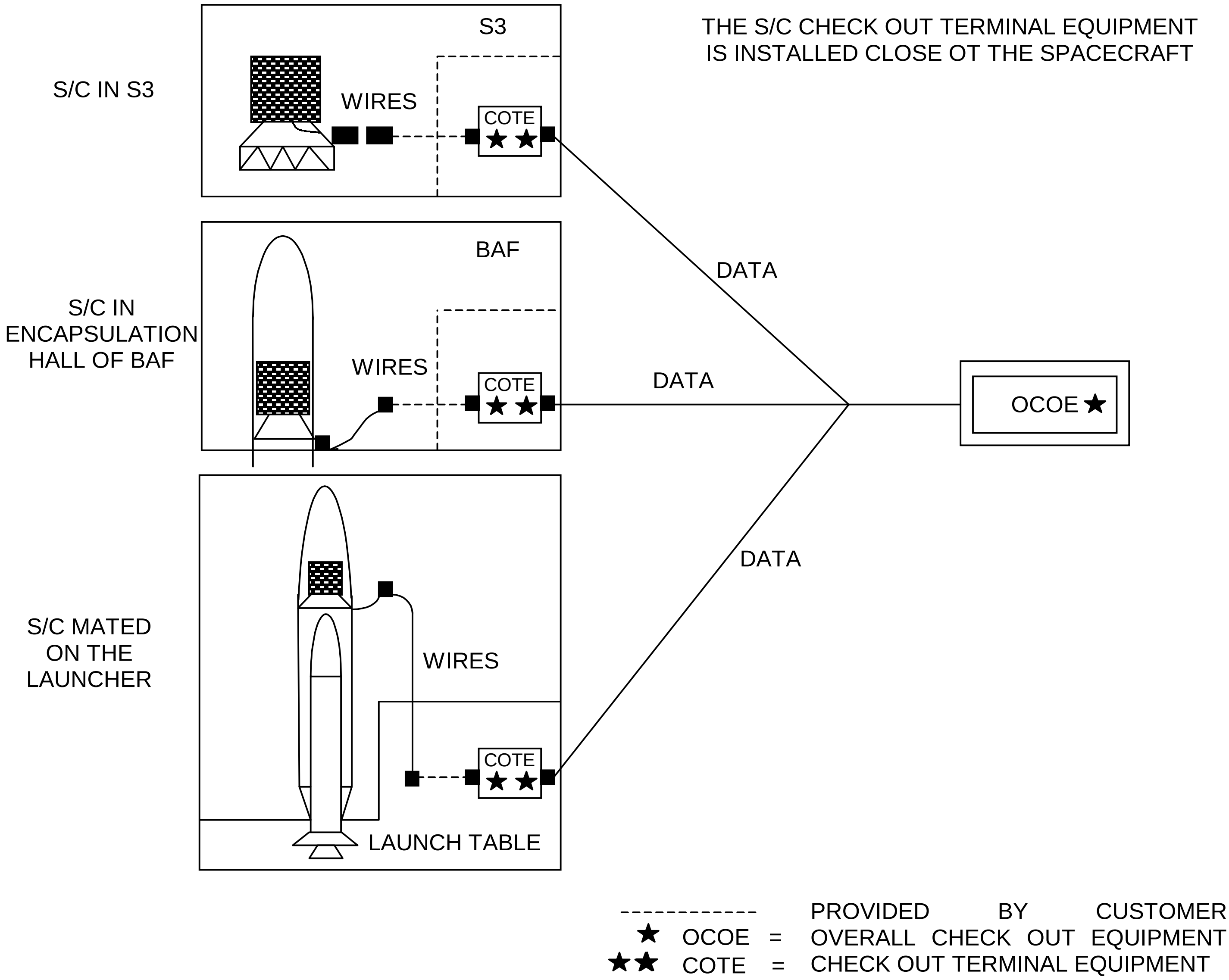


Figure 5.4.3.11.c - Spacecraft Remote Control Configuration for Combined Operations

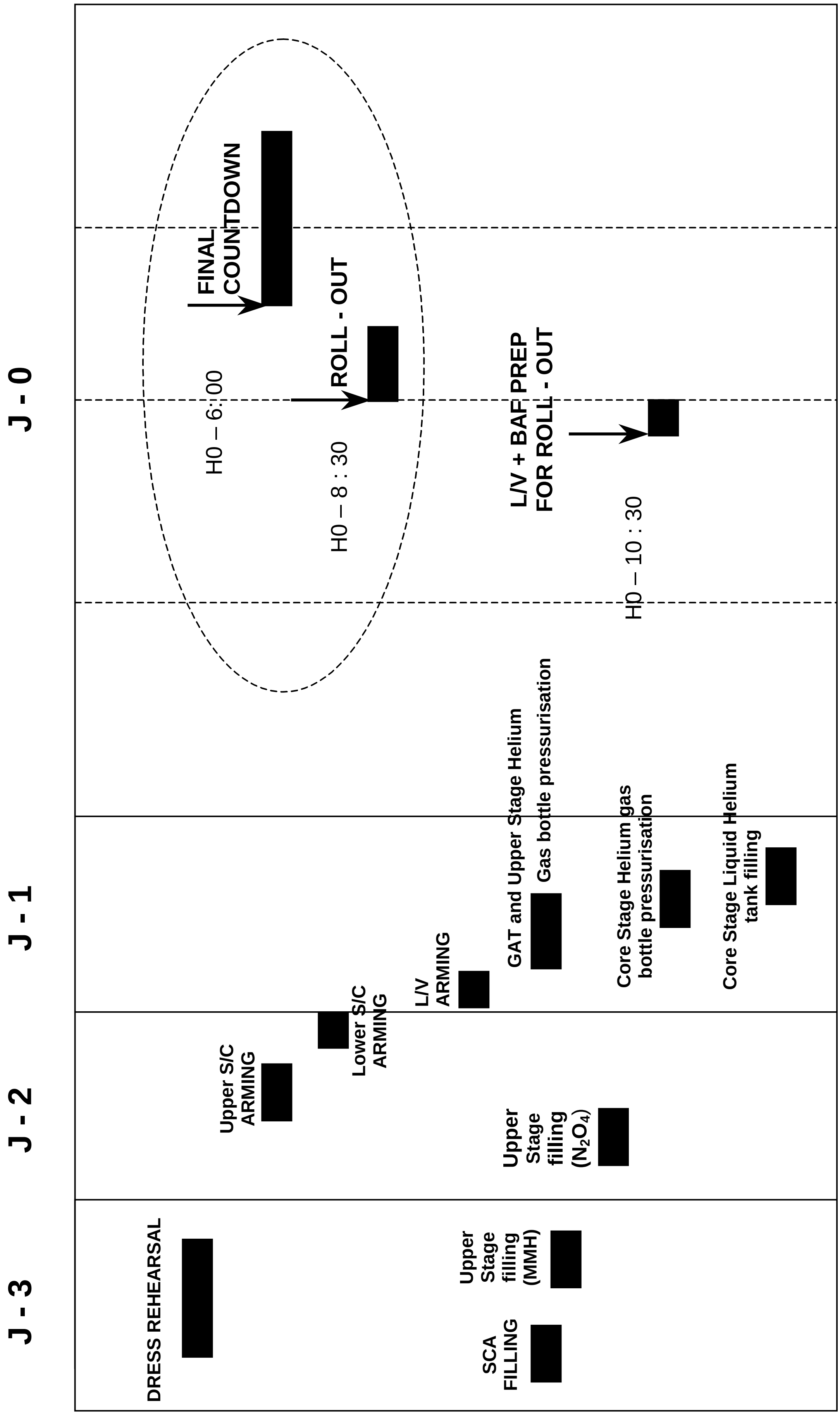


Figure 5.4.3.11.d - J-3 to J0 Typical Flow Diagram

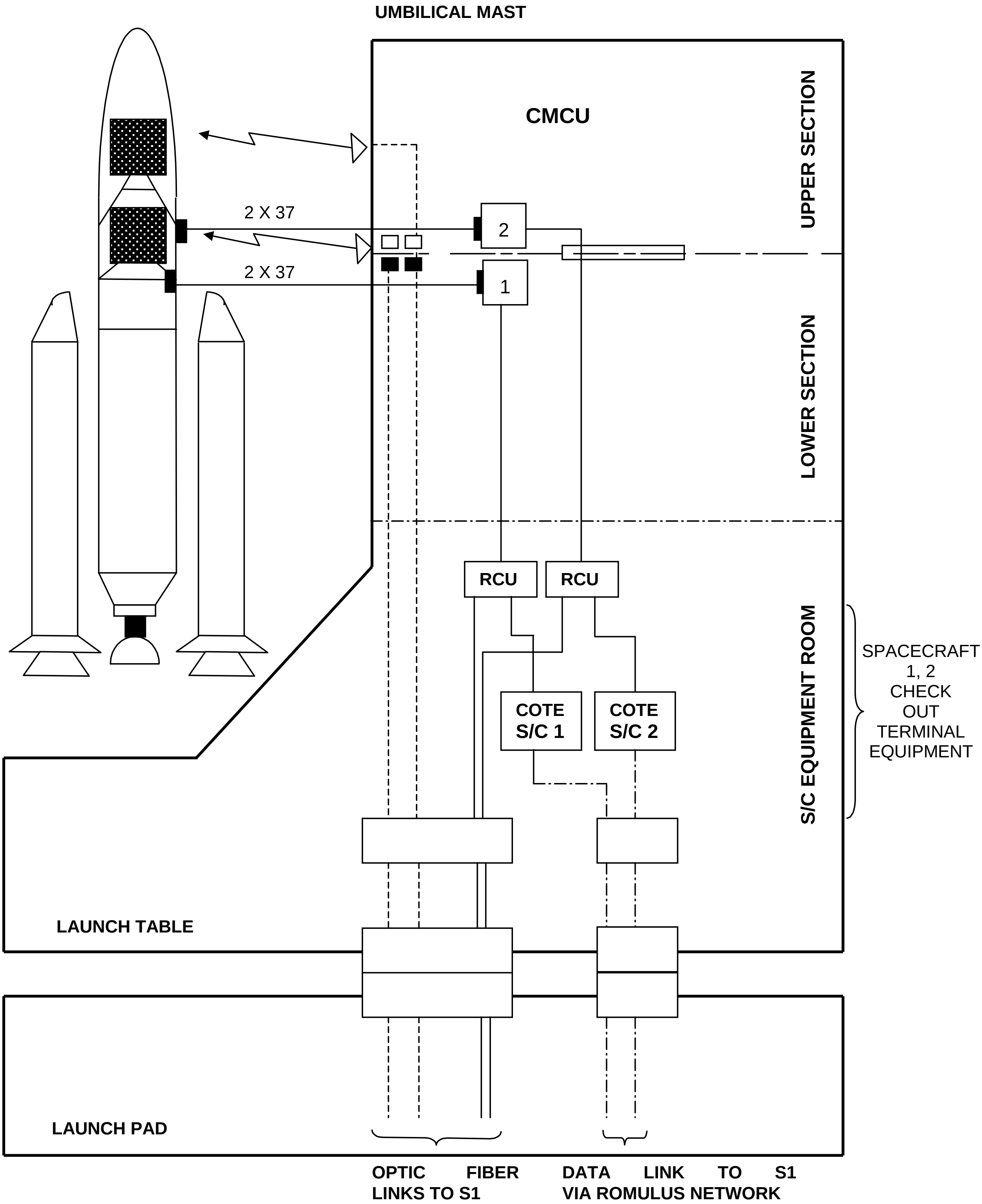


Figure 5.4.3.11.e - Principle of Spacecraft / Launch Pad Interfaces

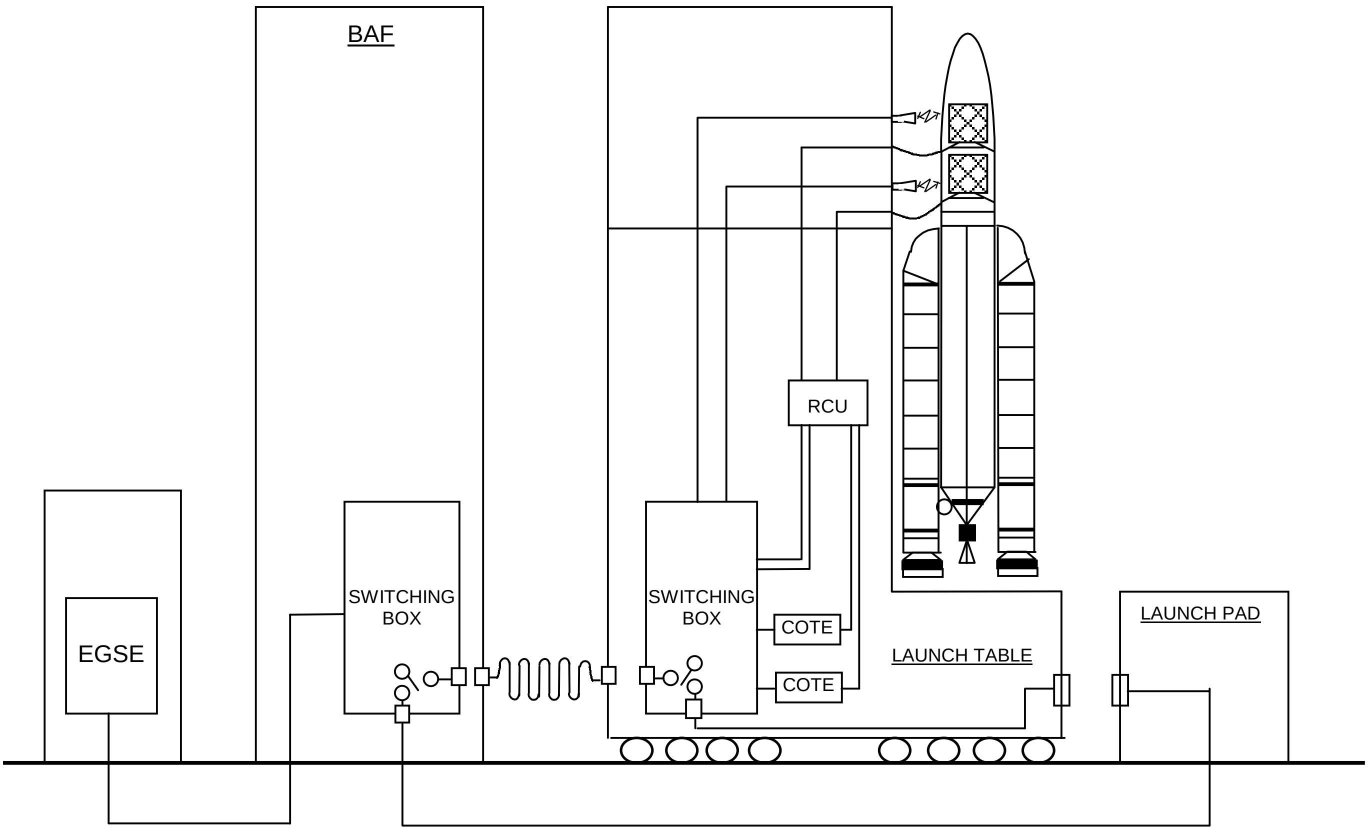


Figure 5.4.3.11.f - Principle of Spacecraft Interfaces during Transfer (TBC)

5.5. Operational organization

Responsibilities are defined as below:

PDG Arianespace - Chief Executive Officer (responsible of the Arianespace's commitments - Flight Director)

DG Arianespace – Chief Operating Officer

DMS (*User*) Spacecraft Mission Director ("Directeur de la Mission Satellite"). Responsible for checking the compatibility of his spacecraft mission objectives with the capability of the launch system. The CM may not proceed with the launch without the agreement of the DMS.

CPS (*User*) Spacecraft Project Manager ("Chef de Projet Satellite"). The CPS delegates preparation, activation and checkout of the spacecraft to the Spacecraft Preparation Manager (RPS).

Note: *The DMS or CPS is responsible for synthesis of reports (spacecraft preparation and satellite orbital ground station network).*

RPS (*User*) Spacecraft Preparation Manager ("Responsable de la Préparation Satellite"). Responsible for the preparation, activation and checkout of the spacecraft.

RCUA (*AE*) Ariane Payload Manager ("Responsable Charge Utile Ariane"). Responsible for the compatibility between the launch objectives and the Ariane Launch system.

ARS (*User*) Satellite Ground Stations Network Assistant ("Adjoint Reseau Stations sol satellite") Responsible for liaison between the CSG control room and the Satellite Orbital Operations Centre.

CPAP (*AE*) Ariane Production Project Manager ("Chef de Projet Ariane Production") Responsible of the Ariane Design Authority.

CG/D Range Director.
Delegates:
1) preparation, activation and operational coordination of the CSG facilities and Ariane down-range stations to the Range Operations Manager (DDO).
2) safety of persons and property to the Safety Officer.

CM (*AE*) Mission Director ("Chef de Mission") Responsible for preparation and execution of the launch campaign.

DDO (*CSG*) Range Operations Manager ("Directeur d'Opération") Responsible for the preparation, activation and operational coordination of the Range facilities and Ariane down-range stations.

RMCU (*CSG*) Payload facilities Manager ("Responsable des moyens charge Utile") Responsible for EPCU maintenance and operation technical support.

RS (*CSG*) Safety Responsible ("Responsable Sauvegarde") Responsible for the safety of persons and property.

COEL (*AE*) Launch Site Operations Manager ("Chef des Opérations Ensemble de Lancement") Responsible for the preparation, activation and checkout of the launch vehicle and launch-complex facilities. Coordinates all operations on the launch pad (Launch Tower and Launch Centre).

ACU (*AE*) Payload Deputy ("Adjoint charge utile"). COEL assistant for the Launch System/Payload combined operations coordination.

ISLA (*CSG*) Launch Area Safety Officer ("Ingénieur Sauvegarde Lancement"). Represents the Safety Officer on the launch site.

ISCU: (*CSG*) Payload Safety Officer ("Ingénieur Sauvegarde Charge Utile"). Responsible for control of the payload hazardous operations.

A typical operational countdown organization is presented figure 5.5.a.

A typical control centre configuration for the above personnel during countdown is shown in figure 5.5.b.

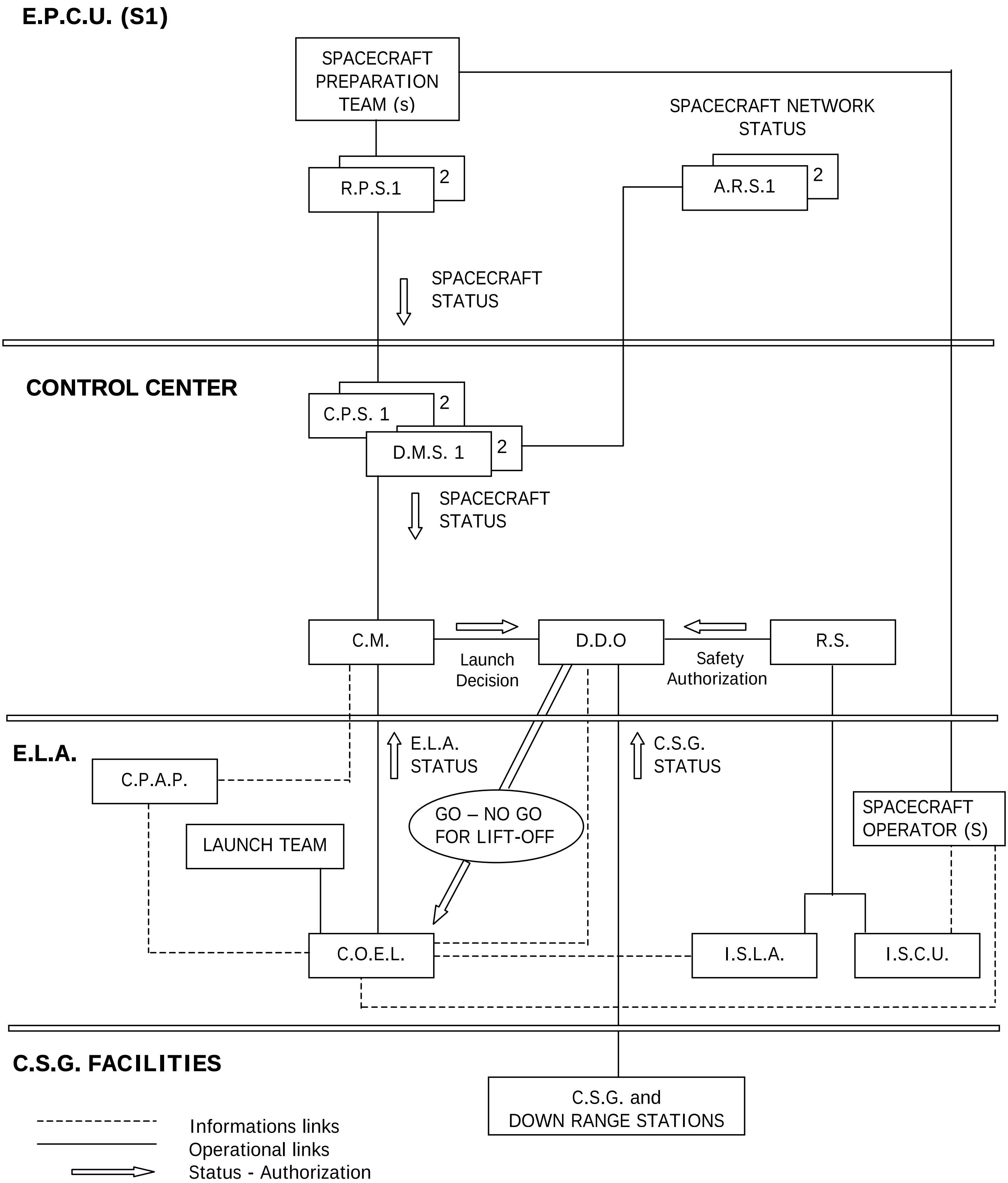


Figure 5.5.a – Typical Operational Countdown Organization

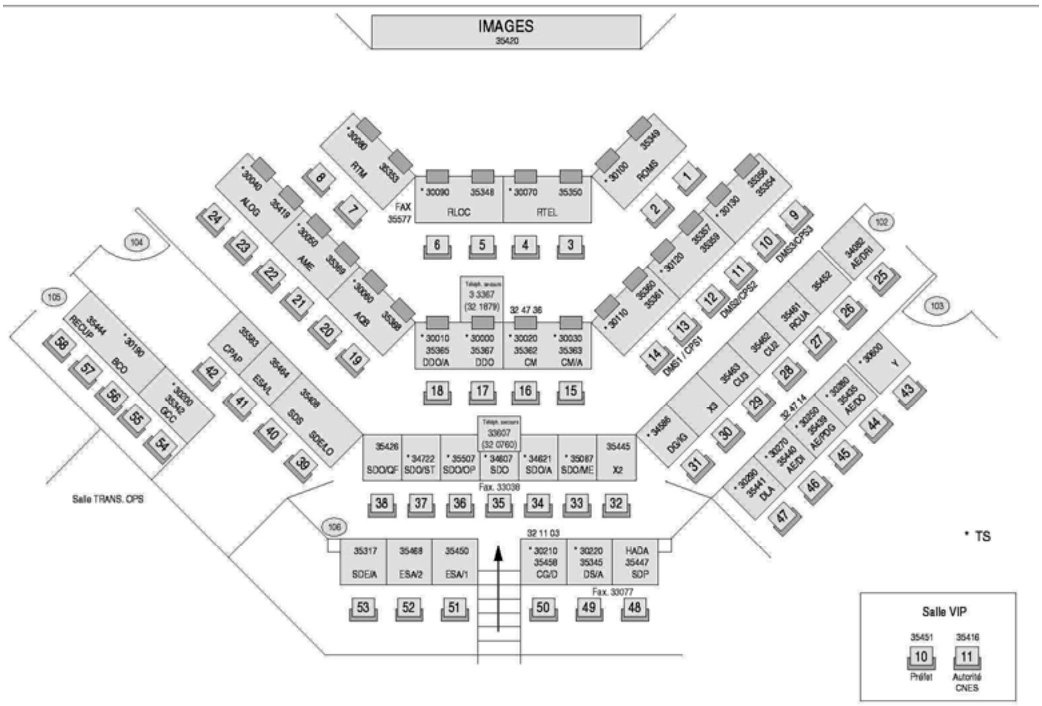


Figure 5.5.b – Typical Control Centre Configuration for Ariane Launch

5.6. Launch constraints

5.6.1. Launch Window

5.6.1.1. Definitions

a) Launch Period:
A period of two consecutive calendar months which will allow the launching of a User's spacecraft with daily Launch Window possibilities.

b) Launch Slot:
One calendar month within a Launch Period.

c) Launch Day:
The day of the Launch Slot, during which the Launch Window starts, selected for launching Ariane and its payload with the agreement of the User(s) and Arianespace.

The latest acceptable Launch Day is scheduled 10 days earlier than the end of the Launch Slot.

d) Instant of launch
Launch vehicle lift-off time, defined in hours, minutes and seconds, within one Launch Window.

e) Satellite Injection Window(s) (SIW):
Daily limited window(s) during which satellite injection into the required orbit is achievable.

f) Launch Window(s) (L/W):
A Launch Window starts at the beginning of the Satellite Injection Window(s) advanced by the Ariane powered flight time.

Daily L/W duration is identical to SIW duration.

g) Launch capability:
The launch capability starts at the end of the countdown and terminates at the end of the LWs requested by the User. This launch capability can amount to 3 hours.

5.6.1.2. Procedure for dual GTO launches

- The satellite reference dual launch window will be presented in the DUA and will be agreed upon by the Customer and Arianespace at the Preliminary Mission Analysis Review. The calculation will be based on the following reference orbit and time.

  Reference time: Time of the first passage at orbit perigee in UT hours. This first passage may be fictitious if injection occurs beyond perigee.

  Reference orbit (osculating parameters at first perigee):

Apogee altitude:	35 946 km at first apogee
Perigee altitude:	560 km
Inclination:	7°
Argument of perigee:	178°
Longitude of descending node:	10° West (with reference to Greenwich Meridian)

- The final launch window calculation will be based on actual orbit parameters in terms of lift-off time.

- The final launch window will be agreed upon by the Client(s) and Arianespace at the Final Mission Analysis Review and no further modification shall be introduced without the agreement of each party.

5.6.1.3. Constraints for dual GTO launches

The Ariane Authority requires daily common launch windows of at least 45 minutes in order to allow the possibility of a minimum of two launch attempts every day.

In order for this requirement to be met, the spacecraft launch window corresponding to the reference orbit and time defined above must contain at least the window described in Fig. 5.6.1.3.a for the launch period of interest.

<u>Note</u>:

- The physical and mathematical definition of the minimum window are as follows: The daily window is 45 minutes long. The opening of the window corresponds to a solar aspect angle of 65° with respect to the reference AMF attitude which permits instantaneous transfer from the reference GTO orbit to geosynchronous orbit at apogee 6 (when the line of apsides is collinear with the line of nodes).

- Reference AMF attitude:
  Right ascension: perpendicular to radius vector at apogee 6
  Declination: - 7.45° with respect to equatorial plane.

5.6.1.4. Constraint for single GTO launches

The daily launch window will be at least 45 minutes long in one or several parts.

5.6.1.5. Constraints for non GTO orbits

At User's request, daily launch windows shorter than 45 minutes may be negociated after analysis.

5.6.2. Launch postponement

If the launch does not take place inside the Launch Window(s) of the scheduled Launch Day, the launch will be postponed by 24 or 48 hours depending on the situation, it being understood that the reason for postponement has been cleared. Launch time (H0) is set at the start of the new Launch Window and the countdown is restarted at H0 – TBD hours.

5.6.3. Engines shutdown before lift-off

In case of launch abort, the new launch attempt will be possible between J0 + 2, the earliest, and in case of launch vehicle engine change, J0 + 10. In that case the launcher will be brought back to the BAF.

5.7. Orbital operations support network

Satellite orbital operations are not an Arianespace responsibility.

However Arianespace can help the User to define and/or choose the orbital operations support network which best suits his requirements.

5.8. Evaluation of parameters at injection

Between H0 + 40 minutes and H0 + 1 hour the Ariane Authority will provide the User with a composite satellization diagnosis. This information includes an estimate of orbital parameters at injection (3rd stage cut-off) and 3rd stage attitude just before payload separation (see also para. 6.4.6.1).

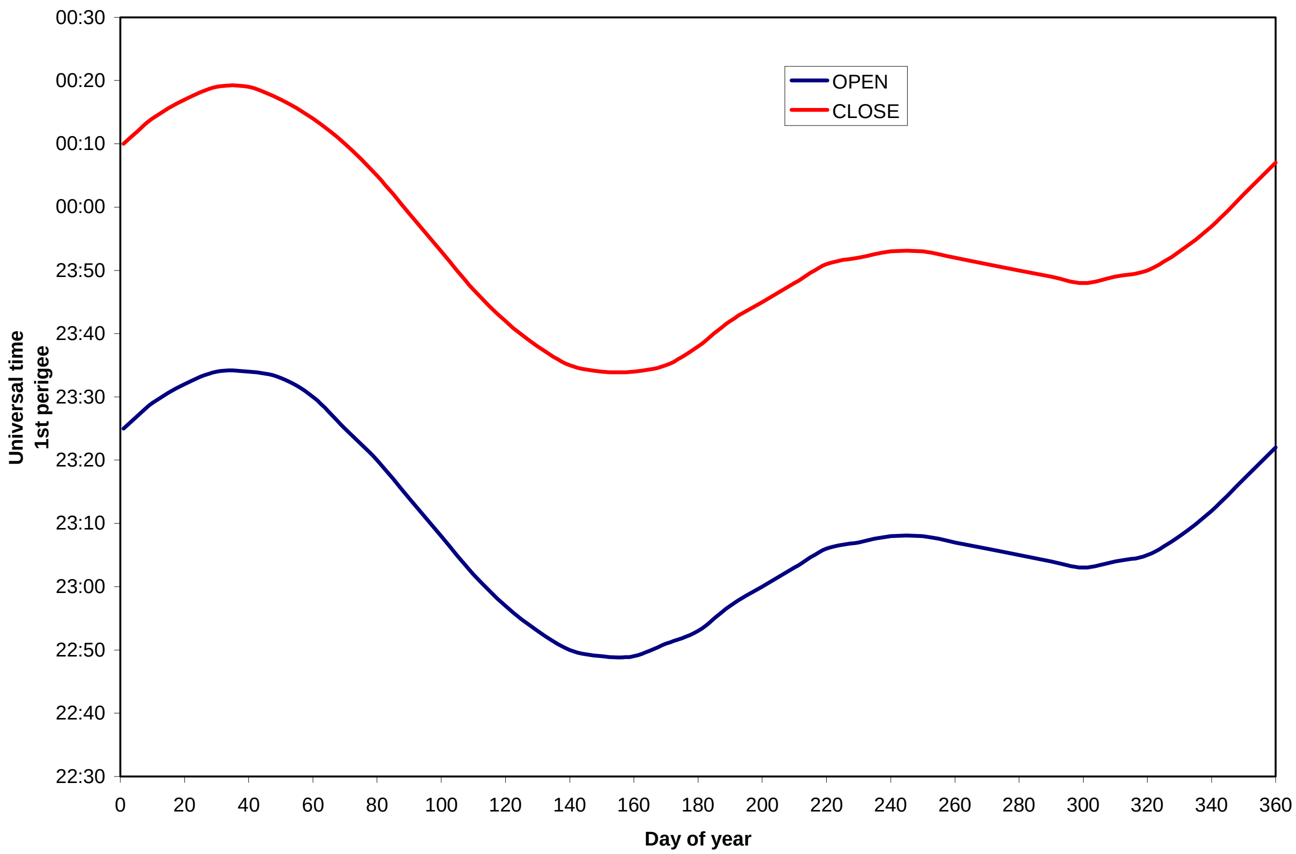


Figure 5.6.1.3.a – Minimum Launch Window at First Perigee Passage

Documentation — Chapter 6

This chapter describes the documentation which will become applicable when the Ariane launch system is adopted by a User.

6.1. The Ariane mission integration schedule

The documentation system and activities associated with an Ariane mission typically cover a 24 months period as shown in figure 6.1.a. This schedule may be modified to suit the User's requirements.

The activities shown in figure 6.1.a. are typical for a first-time Ariane mission; repeat missions of an identical nature may only require the reviews and an update of the analyses and associated documents.

6.2. Interface management

Interface Management is based on the Interface Control Document (DCI) which is issued by Arianespace using inputs extracted from the technical annexes of the Launch Service Contract and from the "Application to Use Ariane" (DUA) provided by the User.

6.2.1. Application to use Ariane

("Demande d'Utilisation Ariane" - DUA)
Refer to annex 3.

The User is required to issue a DUA in which the spacecraft interfaces with the launch system are defined i.e.:

a) Mission characteristics (orbit, orientation at separation, operations after separation,...),

b) Spacecraft data (mass, alignment, inertias, geometrical data, electrical and radio electrical interfaces, hazardous systems,...).

c) Launch preparation at CSG (use of EPCU buildings including storage areas, communications networks requirements, spacecraft prelaunch operations on the launch site and countdown operations).

d) Spacecraft development and test plan.

DUA detailed contents list can be provided to the User on request.

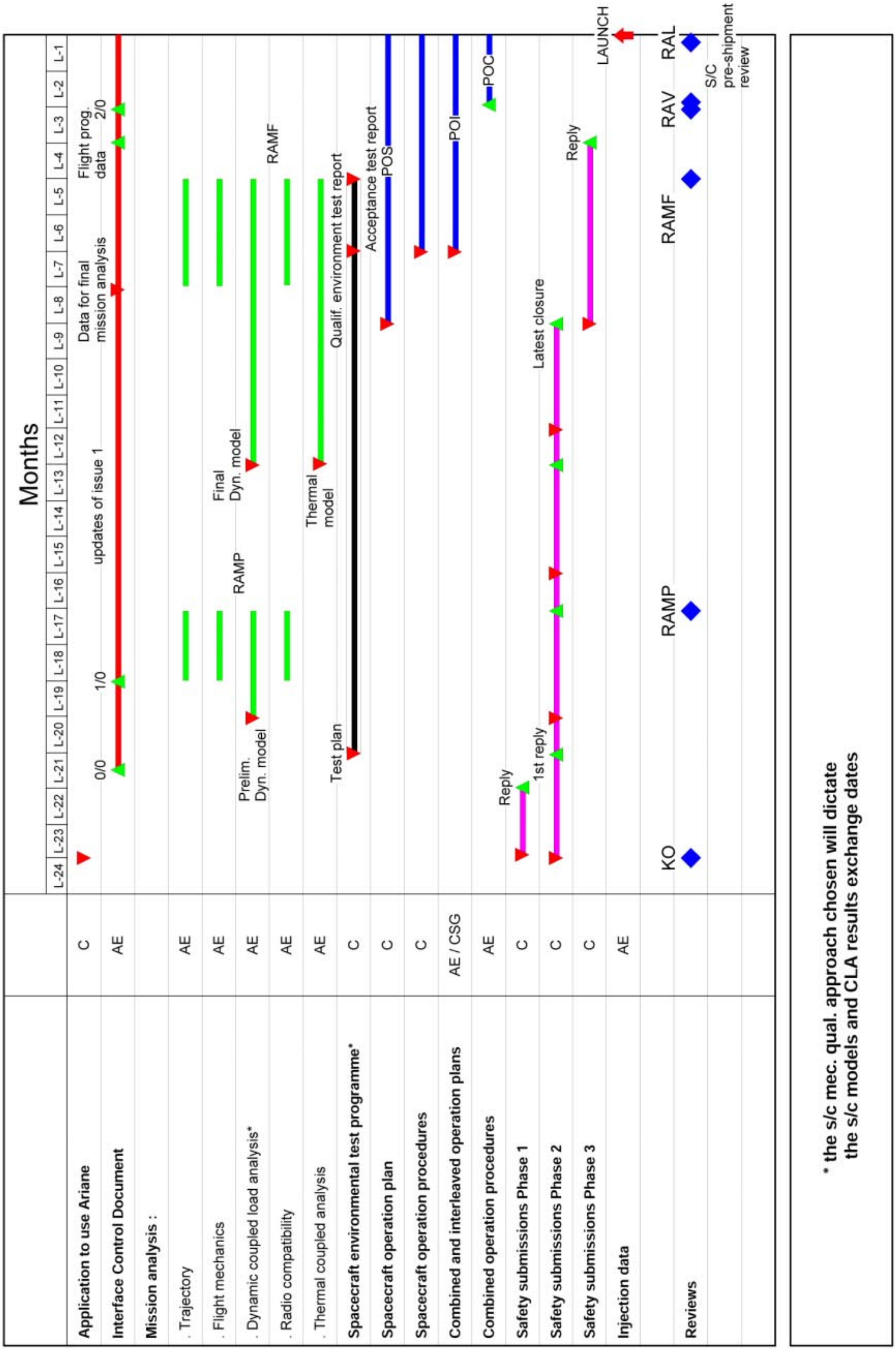


Fig. 6.1.a – Typical time schedule of documentation and reviews

6.2.2. Interface Control Document

("Dossier de Contrôle d'Interface" - DCI)

Arianespace prepares the DCI in response to the DUA and the technical annexes of the launch Service Contract. The DCI collates all interface requirements common to the launch system and the spacecraft, and illustrates their respective compatibility.

The DCI is approved by both Arianespace and the User and is maintained under formal configuration control until the launch.

After approval, the DCI becomes the basic and sole working document with respect to technical aspects and identification of the operational activities.

6.3. Safety Baseline Documents

6.3.1. General

CSG is responsible for drawing up Safety Regulations, and ensuring that they are observed. All launches from the CSG require approvals from Ground and Flight Safety Departments; these approvals cover launch vehicle-payload hazardous systems and the flight plan respectively. In order to obtain this approval, a User has to demonstrate that his equipment and its utilization comply with the provisions of the Safety Regulations. This demonstration is achieved in a number of stages, by the submission of documents defining and describing the hazardous elements and their operation. Submission documents are prepared by the User and forwarded to the Ariane Authority.

6.3.2. Submission procedure

This procedure, defined in C.S.G. Safety Regulations RS, CSG Vol.2 - Fasc. 3 and summarized hereafter, aims at a mutual understanding of problems, and their solutions, from the start of the project onwards in order to avoid loss of time and money resulting from the need for late modifications to the design or manufacture of systems classified as hazardous by CSG. Documents related to a given project are submitted in three phases:

Phase 1 Submission:

The User prepares a file containing all the documents necessary to inform CSG of his plans with respect to hazardous systems.
This file contains a description of the hazardous systems. It responds to all questions on the hazardous items check list given here after.

A safety check list is given in the CSG Safety Regulations to help for the establishment of
the submission documents, its deals with the following topics:

1. ELECTRO-EXPLOSIVE DEVICES

1.1. Description
1.2. Location, function, date and place where fitted to spacecraft
1.3. Safety

2. SOLID PROPELLANT MOTORS

2.1. International classification
2.2. Manufacturer and references
2.3. Has it been used previously ?
2.4. Description
2.5. Ignition system
2.6. Firing and monitoring circuit
2.7. Storage and transfer containers
2.8. Associated ground support equipment

3. LIQUID PROPELLANT MOTORS

3.1. Nature and quantity of propellants
3 2. Propulsion system
3 3. Associated ground support equipment

4. ATTITUDE CONTROL (see § 3)

5. PRESSURE LEVELS

5.1. Nature of fluids
5.2. Tanks
5.3. Associated ground support equipment

6. GROUND SUPPORT EQUIPMENT

7. BATTERIES

7.1. Type, description
7.2. Pressurization (§ 5)
7.3. Hazardous fluids
7.4. Charge

8. RADIATIONS

8.1. Non-ionising radiations
8.2. Ionising radiations

9. INTERFACES

9.1. Mechanical interfaces
9.2. Electrical interfaces

10. MISCELLANEOUS

- Waivers
- Other safety problems not so far dealt with

The document shall cover all safety related activities: component choice, safety and warning devices, fault trees for catastrophic events, and in general all data enabling risk level to be evaluated.

CSG will study this submission, classify the hazardous systems described, and declare any special requirements imposed by its Safety Departments.

Phase 2 Submission:

The User submits the hazardous systems manufacturing, qualification and acceptance documentation as soon as it becomes available. This must satisfy the requirements laiddown by CSG at the end of Phase 1. This documentation gives the requirements for providing EPCU equipment or facilities to be used during the launch campaign, and all other documents required by CSG during phase 1 and 2 submissions. It also defines the policy for checking and operating all systems classified as hazardous.

CSG checks that the documentation delivered in phase 2 complies with the requirements specified in Phase 1, states its intentions concerning verification of systems classified as hazardous, and defines the draft procedure to be applied during spacecraft activities in Guiana.

Phase 3 Submission:

The User submits a verification and operating procedures for systems classified as hazardous, with detailed description of verification policy and its execution.

After implementation of all changes that are considered necessary, CSG accepts the procedure. This becomes the sole authorized document to be applied by the User during the launch campaign, under the supervision of CSG Ground Safety Department.

6.3.3. Time schedule for safety activities

In the general interest, that the User completes the safety questionnaire well ahead of the formal submission phases, so that the earliest possible allowance can be made in designing the spacecraft on-board and ground equipment.

The following time-schedule for formal submissions shows the requested deadlines working backwards from the launch date L.

SAFETY SUBMISSIONS TIME SCHEDULE

Typical schedule	Safety Submissions	Spacecraft Milestone
Earlier than L-24 months	Phase 0 preliminary submission	Contract
L-24 months	Phase 1 submission	
L-21 months (or 3 months after submission phase 1)	Response to phase 1 submission with classification of hazardous systems	PDR
As soon as available	Phase 2 submission (definition documents for systems classified as hazardous)	
3 months later	Response to phase 2 submission	CDR
L-8 months	Phase 3 submission (hazardous procedures)	
L-3 months	CSG approval of hazardous procedures	RAVS

Note: For an already developed spacecraft, phase 1 and phase 2 submissions are initiated as soon as the documentation is supplied by the User. The Safety Departments response is then provided within 3 to 4 months in order to be available for the spacecraft CDR. Such a short safety procedure allows the launch of a qualified spacecraft to be considered only 12 months after the Ariane launch system has been selected by the User.

Safety meetings between CSG safety departments and the User are recommended before CSG's response to submission phases.

6.4. Mission analysis

6.4.1. Introduction

A Mission Analysis is conducted to ensure that the mission objective can be achieved (reliable spacecraft injection into the required orbit and in the correct attitude).

The studies relate to flight plan and environment and are organized in two stages:

- A Preliminary Mission Analysis mainly concerned with the compatibility of the spacecraft design with the Ariane environment (see para. 6.4.2).

- A Final Mission Analysis mainly concerned with the actual flight plan and the final flight predictions covering, when applicable, the dual launch configuration (see para 6.4.3).

At the completion of each step, a Mission Analysis Review (RAM "Revue d'Analyse de Mission") is held based upon the issued Mission Analysis Documentation (DAM '"Dossier d'Analyse de Mission").

6.4.2. Preliminary Mission Analysis

Arianespace performs a Preliminary Mission Analysis which includes the following studies:

- preliminary trajectory and mission sequence,
- preliminary flight mechanics study,
- preliminary dynamic coupled loads analysis,
- preliminary radio frequency compatibility study.

a) In the case of a non-standard GTO mission the *preliminary trajectory study* enables the feasibility of the required orbit and the associated performance margin to be established. The resulting trajectory is then used as input data for various analysis such as orbit dispersion, loads, thermal, separation sequence and safety.

   For a standard GTO mission, the standard trajectory document is issued to the User.

b) The *preliminary flight mechanics study* allows Arianespace to:
   - verify the feasibility of the required orientation,
   - define the necessary separation energy,
   - verify the clearance at separation,
   - determine the kinematic conditions after separation,
   - issue a preliminary sequence of events,
   - verify the orbital long-term clearance; in the event that a problem area is identified, corrective action will be recommended to the User.

c) The *preliminary dynamic coupled load analysis* allows Arianespace to produce the first prediction of the in-flight loads applicable to the User's spacecraft Using a preliminary spacecraft dynamic model provided by the User and conforming to the Ariane specification SG-0-01, this study:

   - performs the modal analysis for the composite launch vehicle and its payload,

   - describes the dynamic responses of the spacecraft for the most severe longitudinal and lateral load cases induced by the launch vehicle,

   - gives, at the nodes selected by the User, min-max tables and time histories for forces, accelerations and relative deflections, as well as Ariane/Spacecraft interface acceleration and force time histories,

   - allows the User to verify the validity of spacecraft dimensioning and to adjust its qualification test plan if necessary, after discussion with the Ariane Authority.

d) The *preliminary radio frequency compatibility study* allows Arianespace to check the compatibility between frequencies (and their harmonics) used by the launch vehicle, the ground stations and the spacecraft during launch operations (including flight). This study is based upon a spacecraft frequency plan (including intermediate frequencies) that the User has to provide within the DUA. The housekeeping telemetry and telecommand of the spacecraft may be subject to change on request of ARIANESPACE up to 20 months before launch.

6.4.3. Final Mission Analysis

Arianespace performs the Final Mission Analysis covering the following studies:

- Final trajectory and mission sequence,
- Final flight mechanics analysis,
- Final dynamic loads analysis,
- Thermal environment,
- Final radio frequency compatibility,
- and, when applicable, dual launch compatibility.

a) *The final trajectory study defines*:
- The actual launch vehicle data to be used (mass breakdown, propulsion parameters adjustments), the actual launch vehicle payload data and the associated launch vehicle performance,
- The flight event sequence for the on-board computer,
- The guidance parameters for the on-board computer,
- The position, velocity and attitude of the vehicle during the boosted phase.

b) The *final flight mechanics study* repeats the studies performed during the premilinary analysis but takes into account the actual Ariane payload parameters and so enables Arianespace to:

- define the data to be used by the on-board computer for the orbital phase (manoeuvres, sequence),
- predict the clearance between the separated elements in orbital flight.

c) The *final coupled loads analysis* enables Arianespace to define the final prediction for in flight loads. Using a test-validated model provided by the User conforming to the Ariane specification SG-0-01, this study allows Arianespace:

- to verify, or adjust if necessary, the Spacecraft Acceptance Test Plan, and associated notching procedure when applicable,

- to verify that the Ariane payload does not affect the behaviour of the launch vehicle or its stability.

d) The *thermal environment study* is required to predict the temperatures during count down and flight. Using a thermal model provided by the User conforming to the Ariane specification SG-1-26, this study covers the period from spacecraft on Ariane in the launch tower up-to the injection into the desired orbit.

The study allows Arianespace to adjust the ventilation parameters during count down (tower removed) in order to satisfy, in so far as the system allows it, the temperature limitations specified for the spacecraft.

e) The *final radio frequency compatibility study* considers the actual launch configuration.
The study involves the examination of possible spurious emission frequencies and the susceptible frequencies of the receivers; in case of conflict the study will extend to the analysis of possible solutions either on the launch vehicle or on the payload.

f) The *dual launch compatiblity study* analyses the results of all mission analysis studies to ensure compatibility between spacecraft to be launched as a combined Ariane payload oad.

The aspects covered in the particular studies mentioned earlier are reviewed during the course of this study and are analysed with the focus on possible interference between spacecraft.

A simulation is performed of the motion of the elements after separation and up to apogee motor firing (for geostationary launches), including spacecraft manoeuvres in GTO, in order to check long term collision avoidance, thermal flux and contamination aspects (due to AKM firings).

6.4.4. Spacecraft environment test file

The User is required to provide the Ariane authority with the spacecraft environment test plan, describing the test called for in paragraph 4.6.1. This plan is analysed at the time of the final Mission Analysis Review.

The User will then submit analysis and synthesis files resulting from the tests. These files are analysed at the Spacecraft Flight Readiness Review ("Revue d'Aptitude au Vol Satellite").

6.4.5. Payload mass characteristics

The mass of the payload in its final launch configuration must be notified to the Ariane authority prior to the Launch Readiness Review (RAL).

6.4.6. Post-launch documents

6.4.6.1. Inspection data

Arianespace will give first diagnosis and information sheets to the User before H0 + 60 min., concerning the orbit characteristics at injection (3rd stage cut-off) and attitude of the spacecraft just before the spacecraft separation.

6.4.6.2. Orbital tracking operation report

Arianespace requires the User to provide orbital tracking data on the initial spacecraft orbits including attitude just after separation, for back-up evaluation of launch vehicle performance.

6.4.6.3. Launch evaluation report.

Arianespace draws up a report on the launch operations, based on processed launch vehicle telemetry and tracking data, showing the performance achieved and reporting on the behaviour of the launch vehicle and its subsystems.
A section of this report covering all launch vehicle/payload interface aspects is distributed to the User.

6.5. Launch preparation and range operations

The documentation necessary for launch operations is generated from the Launch Requirements Document (DL). As far as the spacecraft is concerned, the following data are used as input for writing the DL:

- the approved DCI, taken as a specification,
- the Spacecraft Operations Plan (POS) provided by the User,
- the Interleaved Operation Plan (POI),
- and the master-schedule of the Combined Operation Plan (POC) issued by Arianespace and taking account of both the POS and the Launch Vehicle Operation plan.

The POI and the POC master schedules are submitted to the User for approval. The Ariane Payload Sections of the DL are submitted to the User for comment.

In parallel with this activity, procedures are issued, and phase 3 safety formalities are completed in order to have all the necessary documentation prepared and approved in time for the Flight Readiness Review (RAV).

6.5.1. Spacecraft Operations Plan.

("Plan des Operations Satellite – POS")

The User has to prepare a Spacecraft Operations Plan for the CSG, defining the operations to be executed on the spacecraft from arrival in Guiana: including transport, integration and checkout before assembly, and operations on the Ariane launch site. The POS defines the arrangements for these operations, and describes the facilities required for their execution.

A typical format for this document is shown here below.

1. GENERAL
1 1. Introduction
1 2. Applicable documents

2. MANAGEMENT
2.1. Time-schedule
2.2. Table of weekly activities
2.3. Meetings - Organization - Interface.

3. PERSONNEL
3 1. Organizational chart for spacecraft operations team
3 2. Definition of responsibilities and tasks
3 3. Spacecraft organizational chart for countdown

4. OPERATIONS
4 1. Handling and transport requirements for spacecraft and ancillary equipment
4 2. Tasks for launch operations

5. EQUIPMENT ASSOCIATED WITH THE SPACECRAFT
5.1. Brief description of equipment for launch operations
5.2. Description of hazardous equipment (with diagrams)
5.3. Description of special equipment (Launch Centre, Launch Tower)

6. INSTALLATIONS
6.1. Surface areas
6.2. Buildings (technical and logistic aspects)
6.3. Communications
6.4. Location of offices, assignment of personnel

7. LOGISTICS
7.1. Accomodation
7.2. Transport facilities
7.3. Packing list

6.5.2. Interleaved Operation Plan

("Planning des Opérations Imbriquées POI")

Prepared by the DDO, the POI presents the spacecraft operations range support schedule from the time of arrival of the spacecraft equipment at Cayenne until the POC is started. The POI is submitted to the User(s) for approval.

6.5.3. Combined Operations Plan

("Plan des Opérations Combinées – POC")

The POC identifies all activities involving a spacecraft and a part of the launch vehicle (operations in S3B building when the spacecraft is encapsulated and in the Launch Tower).

Prepared by the COEL from the POS(s) and the Launch Vehicle Operation Plan, insofar as the launch vehicle payload is concerned, this document details the technical characteristics of the launch operations based upon the requirements imposed by both the payload and the launch vehicle.

The POC Master Schedule presents all spacecraft/Ariane activities from the time of spacecraft mating onto the Ariane adaptor until launch. All spacecraft operations during the countdown phase (RF tests, arming sequences, on board power supply switching,...) are included.

The POC Schedule is submitted to the User(s) for approval at the beginning of the campaign.

6.5.4. Launch Requirements Document.

("Demande de Lancement" - DL)

The Launch Requirements Document prepared by the Arianespace Mission Director (CM) together with the Range Operations Manager (DDO) is a synthesis of both launch vehicle and payload aspects in terms of launch campaign preparation.

It defines the mission objectives, launch characteristics, general organization, time schedule and assistance required in terms of personnel, facilities, supply of fluids and support equipment. It is adressed to CSG, and Arianespace/Kourou and to the customer for information.

The inputs for the DL regarding spacecraft related requirements are defined in the DCI the POS, the POI and the POC master-schedules.

6.5.5. Spacecraft operation procedures for the CSG

These procedures are prepared by the User for each operation defined in the Spacecraft Operations Plan (POS). All procedures covering the operation of systems classified as hazardous or those concerning personnel safety have to be submitted to the CSG Safety Departments for approval (see phase 3 submission).

6.5.6. Combined launch vehicle / payload operation procedures

Two types of combined operation are identified: those requiring procedures specific to each Authority, and those requiring common procedures. Common procedures are prepared by the Ariane Authority, and submitted to the Payload Authority(ies) for approval.

6.6. Launch vehicle / payload reviews

Reviews are held, in accordance with fig. 6.1.1, to conclude mission analyses phases, and to authorize blocks of work in the progress of the launch operations.

6.6.1. Mission Analysis Reviews

These reviews are conducted by Arianespace

a) The Preliminary Mission Analysis Review ("Revue d'Analyse de Mission Préliminaire" - RAMP) is based upon the Preliminary Mission Analysis Documentation (DAMP) comprising all reports issued during the Preliminary Mission Analysis (see para. 6 4.2).

   The Spacecraft Authority attends the RAMP. Conclusions from the RAMP lead to the updating of the DCI, and agreement on the spacecraft environmental test plan.

b) The Final Mission Analysis Review ("Revue d'Analyse de Mission Finale" - RAMF)

   In addition to aspects specific to the launch vehicle, the objectives of this review are to check the compatibility of spacecraft qualification status with the mission analysis results, to agree on applicable acceptance test procedures and to confirm the main mission parameters.

This review is held in relation to the Final Mission Analysis Documentation (DAMF) and when applicable, the *dual launch compatibility analysis*. In the latter case, the review is conducted in two stages, the second one involving both Spacecraft Authorities.

The conclusions of the RAMF lead to the updating of the DCI(s) and the release of data for the launch vehicle flight programme.

6.6.2. Launch-vehicle Flight Readiness Review

(Revue d'aptitude au vol du lanceur - RAV)

The purpose of this review is to verify that the launch vehicle, following acceptance tests in Europe, is technically capable of executing its mission. One activity covered by the RAV concerns the examination of launch-vehicle/payload interfaces, with particular reference to the DCI, and the status of the launch preparation documentation (see para. 6.5).
The review is conducted by the Ariane Authority, and shipment of the launch vehicle to the CSG is contingent on a satisfactory conclusion.

The User is invited to attend the RAV.

6.6.3. Spacecraft Flight Readiness Review

("Revue d'aptitude au vol du satellite")

Arianespace requires to be represented at this review, normally held by the User before shipment of the satellite to the CSG. In particular, the Ariane Authority uses this opportunity to obtain the results of environmental acceptance tests, and the actual inertial and mass characteristics of the spacecraft.

6.6.4. EPCU Configuration Acceptance Review

The purpose of this review, held just before the arrival of the spacecraft and associated equipment at the CSG, is to verify that the buildings are configured according to the requirements contained in the Launch Requirements Document.

The configuration status is documented through a compliance certificate issued by CSG and approved by its Quality Control Department.

6.6.5. Combined Operation Release

A technical assessment of the related launch vehicle and spacecraft hardware is held to clear implementation of the POC. This meeting involves the safety department, the User and the COEL for the launch vehicle, with the CM as chairman.

6.6.6. Range Readiness Review

This review is held before the Launch Readiness Review (see para 6.6.7). Its purpose is to check the validation of the range, down-range stations and associated networks. The, review is chaired by the CSG in presence of the CM who approves the configuration on behalf of the Chief Operating Officer of Arianespace.

6.6.7. Launch Readiness Review

("Revue d'aptitude au lancement" – RAL)

This review, conducted by the Ariane Authority, is held at CSG in order to review the overall status of all checks carried out on launch vehicle, payload and launch facilities and to authorize the final operations leading up to launch. The RAL normally takes place just after the launch rehearsal.

A dedicated payload session is requested by the CM to prepare for the main meeting.

Europe's spaceport and Arianespace in French Guiana — Annex 1

1. French Guiana

1.1. Geography (see figs. A2.1 and A2.2)

French Guiana is a French Overseas Department (D.O.M.). It lies on the Altantic coast of the Northern part of South America. It is an equatorial region covering about 92 000 squares kilometers between latitudes 2° and 6° North at longitude 50° West. It is bounded:

a) to the North, by the flat and marshy Atlantic coast covered with a recent alluvial layer,

b) to the West, by the Maroni river, which forms the natural frontier with Surinam,

c) to the East, by the Oyapock river separating Guiana from Brazil,

d) to the South, by the frontier with Brazil, which is formed by the watershed of the Amazon basin.

Most of the territory is covered with equatorial forest, only a coastal strip 1 to 30 km wide being habitable.

1.2. Climate

The climate is of the equatorial type, but is fairly moderate for this latitude, with a temperature generally within a 25° - 30°C range, a low daily variation (5 to 10°C per day) and extreme temperatures of 18° and 34°C.

Despite relatively high rainfall (annual mean 3 m), there are two dry seasons: a short one in February/March with northeasterly trade winds, and the main dry season between July and early December, with easterly trade winds during the day.

The relative humidity is very high with a daily mean value varying between 60 % and 95 % corresponding to 15 to 22 g of water per cubic metre of air.

French Guiana lies outside the hurricane zone, and has light prevailing winds, mainly north-easterly. Despite its geographical situation, the coastal zone has a pleasant climate, breezy and sunny most of the year round.

1.3. Towns and population

The current population of French Guiana is more than 130 000.

The main towns are Cayenne, Kourou and Saint Laurent du Maroni.

Fig. A2-1 – French Guiana and South America

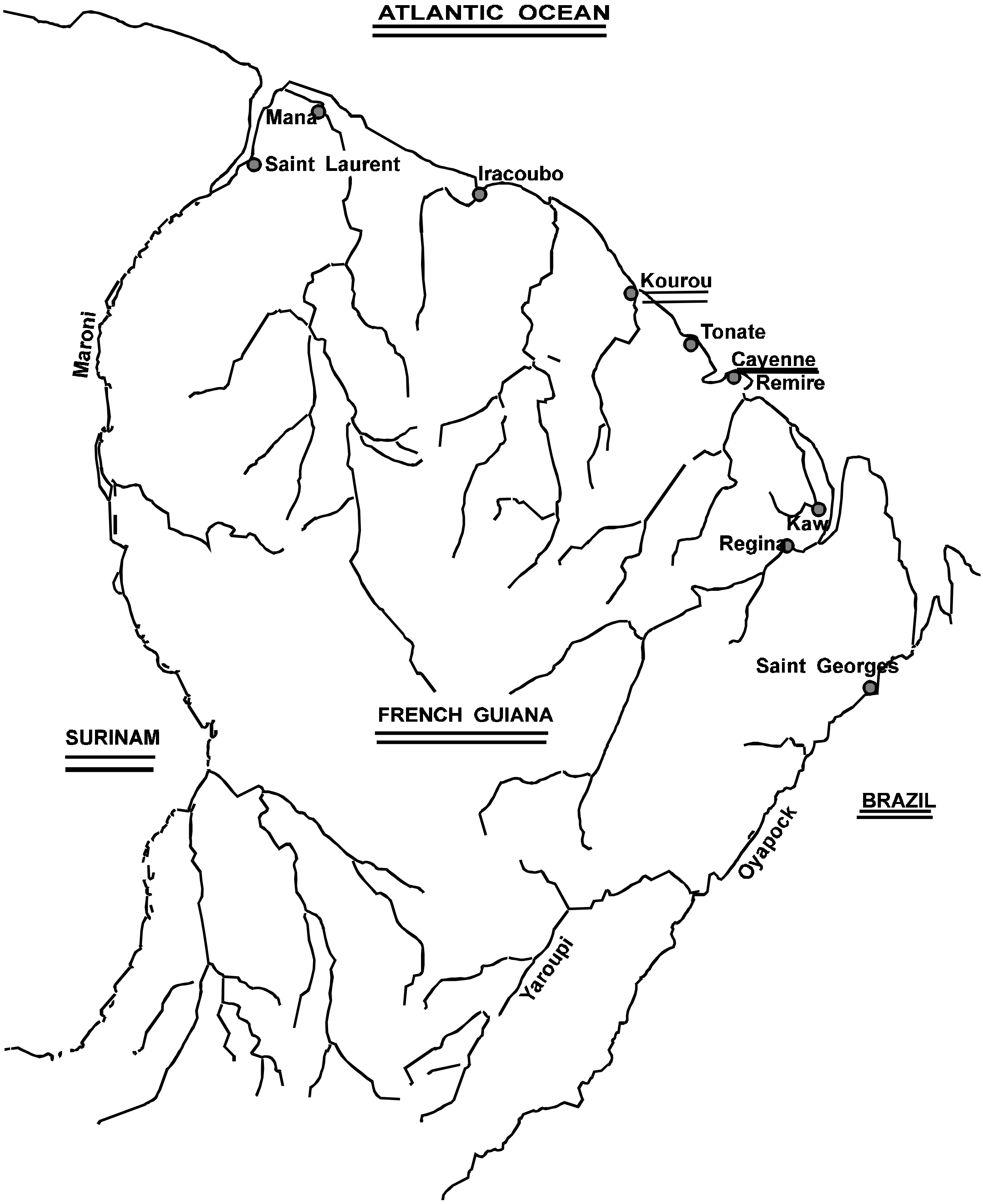


Fig. A2-2 – French Guiana

1.4. Infrastructure and communications

- Sea links

  The port of Cayenne is located in the south of the Cayenne peninsula in Degrad des Cannes. The facilities handle large vessels with 6 meters draught. The port is linked to Kourou by road.

  The harbour facilities allow the container transfer in Roll-On/Roll-Off (Ro-Ro) or in Load-On/Load-Off (Lo-Lo).

  The Pariacabo area is located near Kourou. This facility is dedicated to the transfer of the launcher stages.

- Air links

  Rochambeau international airport at Cayenne has a 3200 meters runway on which Jumbo-jets can land. There are flights every day from and to Paris, either direct or via the West Indies. Regular daily flights with North America are available via Guadeloupe or Martinique.

- Road links

  The North-Westward national road (RN1) links the mains towns of Guyana (Cayenne - Kourou - Sinnamary - Saint-Laurent du Maroni).
  The South-Eastward national road (RN2) links Cayenne, Rochambeau, Roura, Cacao, Regina.

- Telecom

  All towns and facilities in Guiana are linked by telephone telex, telecopy to the international network.

1.5. Health

Yellow fever vaccination is mandatory for any stay in French Guiana.
Malaria is practically absent of the Kourou - Cayenne coastal strip.
Anti-malaria precautions are recommended for persons entering forest areas along river.
Hospital facilities with very complete and up to date equipment are available in Kourou and Cayenne.

1.6. Kourou

The town of Kourou lies on the coast, approximately 65 km north west from Cayenne.

The current population is about 14 000 inhabitants.

The town has:
- church and Oecumenical Centre,
- other facilities such as a swimming pool, a stadium and a sports ground,
- a high-class hotel complex with a total of more than 200 rooms and several kinds of restaurant with seating capacity for more than 600, with international cuisine. Various local and French cuisine restaurants are available downtown.

Kourou town is supplied with electricity main power voltage is 220 - 380 V at 50 Hz.

The town is supplied with drinking water by a pumping station 32 km upstream from the estuary of the Kourou river.

Kourou has all the essential amenities of a modern town such as shops, supermarket, restaurants, and craft trades.

2. The Europe's spaceport

French Guiana's location, close to the Equator, in an area outside the hurricane zone with the possibilities of launches in Northern to Eastern directions over the ocean, and regular air and sea connections were factors which led to the choice of Kourou as the site for the Ariane launch complex.

2.1. General description

The Guiana Space Centre (CSG), now the Europe's spaceport operational since 1968 is managed on behalf of the European Space Agency (ESA) by the Centre National d'Etudes Spatiales (CNES). An agreement between the French government and ESA defines the rights and obligations of each party with regard to ESA's Ariane launch sites and associated facilities.

Within the Europe's spaceport perimeter, the following ESA facilities are namely operated:

- Ariane launch complexes ("Ensembles de Lancement Ariane" - ELA 2 and ELA 3), including facilities required for storage, final

assembly, checkout and launch of Ariane Launch vehicles.

- Liquid nitrogen, liquid oxygen, liquid hydrogen and solid propellant plants.

- Payload preparation complex ("Ensemble de Préparation Charge-Utile" EPCU), with facilities made available to Users for the preparation of their spacecraft.

- Agreements between ESA, CNES and ARIANESPACE define the conditions for utilisation by ARIANESPACE of ELA2, ELA3 and EPCU.

2.2. Role of CNES / CSG

CNES/CSG's role is:

- To provide technical and logistic supports to the Ariane launches such as telecommunication, meteo, plotting, telemetry and tracking to Arianespace and its customers in view to perform the L/V and S/C preparation campaign and the launch.

- To ensure in flight safety and on the range persons and assist safety and protection.

These activities comprise:

- Operation of range and of the down range, stations network.

- Data acquisition and processing from launch vehicles during flight, in real time and post flight.

- General coordination on the range and of the down range stations during ground spacecraft and launcher operations and launch countdown.

3. The Arianespace Establishment in Kourou

The Arianespace Establishment in Kourou was created in January 1982. It is a technical centre in charge of:

- Operations and maintenance of the Ariane launch complexes.

- Support for launch campaigns of Ariane launch vehicles.

Its activities are carried out in close cooperation with CNES/CSG as a subcontractor.

It should be noted that management of the Arianespace Kourou Establishment is independent from CNES/CSG range management and report to Arianespace Operation Directorate.

Items and services for an Ariane launch — Annex 2

Within the framework of the launch contract ARIANESPACE supplies standard items and conduct standard services.
In addition, Arianespace proposes a tailored proposes a tailored service: the General Range Service (G.R.S.) to suit the needs of satellite operations in French Guiana. Optional items and services to cover specific customer's requirements are available on request.

These services are listed in the Technical Annexes of the Arianespace contract, they cover typically:

1. Hardware Supply and Services

ARIANESPACE shall supply the Hardware and Software to carry out the Mission, and provide services to the CUSTOMER as listed hereunder.

1.1. Launch Service Management

General Contract Management:
Contract amendments, payments, planning, configuration control, documentation, reviews, meetings, etc ...

Launch Vehicle Production:
Testing, acceptance, and quality aspects, etc ...

Mission Analyses
Launch Base Operations
Ground and Flight Safety:
Interface with CSG for Safety Submissions.

1.2. Hardware Supply

Launch Vehicle Hardware:
Including strap-on boosters, as applicable.

Launch Vehicle Propellants

One Flight Program

Spacecraft Adaptor:
Including the corresponding separation system.

Umbilical Interface Connectors

Fairing or Dual Launch Support Structure

2 Standard Access Doors:
At authorised locations, for access to the encapsulated Spacecraft.

2 Check-Out Terminal Equipment [COTE] Racks:
Compatible with the ARIANE 5 launch table.

1 Mission Logo:
Design to be supplied at L-6 by CUSTOMER.

1.3. Mission Analysis

Trajectory Study
Separation Analysis (Clearance, Kinematics, Collision)
Orbit Characteristics & Dispersion
Dynamic Coupled Load Analysis
Thermal Analysis
Radiofrequency Compatibility Analyses

Support for S/C Design Reviews
S/C Orbit & attitude data from L/V telemetry (immediately before S/C separation)
Launch Evaluation Report [DEL]

1.4 Operations

Launch Vehicle Operations:
All operations without S/C

Combined Operations [POC]:
S/C – Launch Vehicle Integration

Countdown Execution:
Up to Lift-Off

2. General Range Support [GRS]

The General range Support provides the CUSTOMER, on a lump sum basis, with a number of standard services and standard quantities of fluids (see list hereafter).

Request(s) for additional services and/or supply of additional fluids exceeding the scope of the GRS can be accommodated, subject to negotiation between ARIANESPACE and the CUSTOMER.

2.1. Transport Services

Customer Personnel & Luggage:
Transport from and to Rochambeau Airport and Kourou at arrival departure, as necessary.

Spacecraft & Equipment:
Subject to advanced notice and performed nominally within normal CSG working hours.

Transport ① - ②:
Availability outside normal working hours, Saturdays, Sundays and Public Holidays subject to advance notice and negotiations.

From Cayenne to CSG and return.

Various Freight Categories (standard, hazardous, fragile, oversized loads, low speed drive, etc...).

Limited to 24 10ft pallets (or equivalent) in 2 batches (plane or vessel).

Spacecraft Inter-Site Transport ②:
All CSG Inter-Site Transports of the Spacecraft either inside the S/C container, the ARIANE Payload Container [CCU], or encapsulated inside the Launch Vehicle Composite.

Inter-Site Equipment Transport ②:
All CSG Inter-Site Transports of CUSTOMER Equipment.

Logistics Support:
Support for Shipment and Customs procedures for the Spacecraft and its associated equipment, and for personal luggage and equipment transported as accompanied luggage.

① The following is included in the Transport Service:

- Coordination of Loading/Unloading activities.
- Transport from Rochambeau Airport and/or Degrad-des-Cannes harbour to CSG.
- Return to Airport/Harbour 3 working days after Launch.
- Depalletisation of Spacecraft Support Equipment on arrival to CSG, and dispatching to the various working areas.
- Palletisation of Spacecraft Support equipment prior to departure from CSG to Airport/Harbour.
- All work associated with the delivery of freight by the Carrier at Airport/Harbour.
- CSG Support for the installation and removal of the Spacecraft Check-Out Equipment.

The following is NOT included in the Transport Service:

- The “octroi de mer” tax on equipment permanently imported to Guiana, if any.
- Insurance for Spacecraft and its associated Equipment.

② The maximum temperature to which containers and packing may be exposed during any transport is 35°C.

2.2. Payload Preparation Facilities

The Payload Preparation Complex, with its personnel for support, may be used simultaneously by several customers. Specific facilities are dedicated to the CUSTOMER on the following basis:

EPCU Facilities
Standard conditions for temp. and relative humidity do not exceed 24°C and 55 %, respectively:

Spacecraft Preparation (clean Room)	400 m^2
Lab for Check-Out Stations (LBC)	120 m^2
Offices and Meeting Rooms	220 m^2

Access to the EPCU:
Restricted to authorised personnel only, permanantly controlled by Range Security.

Access to offices, check-out stations and cleanrooms, is controlled through a dedicated electronic card system.

Cleanrooms are permanently monitored by a CCTV camera/tape system.

Access outside normal working hours:
Access to the S1 facilities beyond normal working hours, is authorised, subject to the following restrictions:

- No Range Support Provided.
- No hazardous Operations
- Crane utilisation only by certified personnel
- No changes to the Facilities Configurations

Schedule Restrictions:
Launch Campaign duration is limited to 49 calendar days, from S/C arrival in Guiana, to actual departure of associated equipment.

Extension is possible, but is subject to negociations.

Spacecraft Ground Support Equipment must be ready to leave the range within 3 working days after the Launch.

Transfer of S/C and its associated equipment to the S3 facilities no earlier than 21 working days before Launch.

After S/C transfer to S3, and upon request by ARIANESPACE, the S1 Cleanroom may be used by another S/C.

Range Operations:
Based on 2 Shifts of 8 hours per working day. 3 Shifts per day, and/or Saturday, Sunday or public holiday work is possible, but subject to negotiations.

Standard MGSE:
As per EPCU Manual.

No-break Power Supply:

S1 Building	20 kVA
S3 Building	10 kVA
Launch Pad	10 kVA

Calibration Equipment:
As per EPCU Manual

Storage:
Any storage of equipment during the campaign
2 additional months for propellant storage

2.3. Communication Links

The following communication services between the different Spacecraft preparation facilities will be provided for the duration of a standard campaign (including technical assistance for connection, validation and permanent monitoring):

Service	Type	Number
RF-Link	Ku-Band (optical fiber)	1 TM / 1TC
Baseband Link	Optical fiber	2 TM / 2TC
Data Link	Romulus Network	4, for monitoring & remote control
Umbilical Link	Copperlines / COAX	2x37 pins for S/C umbilical & 2x37 pins for auxiliary equipment
Closed Circuit TV		As necessary
Intercom System		As necessary
Paging System		TBD
CSG telephone		As necessary
Int. Telephone Link 1)	With Access Code	< 10
Facsimile in S1 1)		2
Video Conference 1)	Shared with other users	2 hours daily sessions

1) Traffic to be paid, at cost, on CSG invoice after the campaign.

2.4. Analyses and Operations

Service	Type	Remarks
Chemical Analyses	Propellants	4 complete 10 partial, equiv. to 8 complete
	Gas & fluids particles	40 analyses
	Cleanroom organic deposit	1 weekly
Particle Count	Clean room monitoring	1 per day, one report weekly
S/C Weighing		In EPCU buildings
Adaptor Fit-Check	Mechanical / electrical TBD	At S/C arrival

2.5. Fluid Deliveries

Fluid	Type	Quantity
GN2	N48 at 190 bar	24 B50 bottles
GN2	Ground Supply in EPCU	As necessary
GHe	N55 at 350 bar	24 B50 bottles
IPA	MOS-SELECTIPUR	400 liters
Water	Deionised	As necessary

2.6. Miscellaneous

No-break power:
1.4 kVA in S1 offices for Customer PCs.

Copy machines:
2 in S1 area (1 for secretarial duties, 1 for extensive reproduction); paper provided.

Photo & Film processing:
~ 500 prints (13 x 18 cm) and one broadcast quality video tape (or 16 mm movie) of 15 min duration, to document S/C operations in French Guiana.

Video Transmission:
Coverage of the Launch, signal available at Bercenay (France) and ETAM (USA East Coast).

Video tape:
Launch Coverage (NTSC, PAL or SECAM).

2.7. Additional Services

Bilingual Secretary:
(French/English) during normal working hours.

Photographic Support:
For technical still pictures.

Room Reservation:
In the ARIATEL Hotel resort at Customer's request (cancellation charges, if any, under Customers's responsibility).

Customer Assistance - (Customer & Spacecraft Contractor):
For housing, rental cars, flight reservations, banking, off-duty & leisure activities.

The following list is an abstract of the "Tailored and Optional Services List" available for the customer and which is updated on a yearly basis.

	N°	Latest date for option request (in months)
3. Optional items and services	A xxx	Refer to the applicable Tailored and Optional Services List for the year of the launch
3.1. Launch vehicle hardware		
Pyrotechnic command Electrical command Dry loop command S/C Data via L/V T.M. Radio transparent window Additional access doors		
3.2. Mission analysis	B xxx	
Any additional Mission Analysis, dynamic analysis or flight program work due to changes made by the client		
3.3. Interface tests		
Any loan or purchase of equipment (adaptor, clampband, bolts, separation pyro set) can be envisaged and is subject to previous test plan acceptance by ARIANESPACE.	C xxx	
<u>Mechanical compatibility test with ground test hardware</u>		
<u>Note</u>: Fit-check with flight hardware is performed on the range.		
<u>Mechanical compatibilty test – shock test</u>		
Additional – Shock test performed during same period.		
<u>Electrical or Radio Electrical Check</u>		
3.4. Range operation		
Additional Shipment of spacecraft support equipment from Cayenne to CSG and return.	D xxx	
Extra working shift.		
Transmission of TV Launch coverage to the point of reception requested by Customer.		
Additional spacecraft mass (propellant loading) over the contractual mass depending of the actual vehicle performance		

Format for application to use Ariane — Annex 3

1. Introduction

SPACECRAFT description and mission summary:

Include a 3D view drawing of spacecraft in orbit, an exploded view and the coverage zones (if applicable).

Manufactured by	**Model**	
MASS • Total mass at launch TBD kg • Mass of satellite in TBD orbit TBD kg	*DIMENSIONS* • Dimensions TBD m • Dimensions stowed for launch TBD m • Dimensions deployed on orbit TBD m	
STABILIZATION • Spin* • 3 axis*	*LIFETIME* TBD years	
MISSION SUMMARY • TBD operational channels of TBD bandwith • Travelling wave tube amplifiers: TBD (if used) • Transmit Frequency range: TBD W • Receive Frequency range. TBD W • EIRP: TBD	Telecommunication* Direct broadcasting* Meteorological* Remote sensing*	Scientific* Radiolocalisation* Others*
ANTENNAS (TM/TC) Omniantenna direction and location		
PROPULSION SUB-SYSTEM Brief description: TBD (liquid/solid, number of thrusters..)		
ELECTRICAL POWER Solar array description (L x W) Beginning of life power TBD W End of life power TBD W Batteries description TBD (type, capacity)		
ATTITUDE CONTROL Type: TBD		
COVERAGE ZONES OF THE SATELLITE TBD (figure)		

(*) To be selected.

2. Mission characteristics

2.1. Orbit description (if not standard GTO)

Specify elements:
- semi major axis,
- eccentricity,
- inclination,
- argument of perigee,
- any other elements constrained by the spacecraft,
- performance required.

2.2. Launch window(s) definitions

2.2.1. Constraints and relevant margins

Solar aspect angle, eclipse, ascending node, inclination, right ascension...

2.2.2. Preferred window

Computed using the reference time and reference orbit described in the AR4 User's Manual, the resulting launch window must include at least the ARIANE dual launch window as specified in the User's Manual for any launch period, and is preferably supplied as an electronic file (MS Excel). Constraints on opening and closing shall be identified and justified.

2.3. Separation conditions

2.3.1. Fixed orientation

The desired orientation at separation should be specified by the User with respect to the inertial perifocal reference frame [U, V, W] related to the orbit at injection time, as defined below:

U = radius vector with its origin at the center of the Earth, and passing through the intended orbit perigee.

V = vector perpendicular to U in the intended orbit plane, having the same direction as the perigee velocity.

W = vector perpendicular to U and V to form a direct trihedron (right-handed system [U, V, W]).

For circular orbits, the [U, V, W] frame is related to the orbit at a reference time (specified by Arianespace in relation with the mission characteristics) with U defined as radius vector with origin at the Earth center and passing through the launcher CoG (and V, W as defined above).

In case of 3-axis stabilized mode, 2 of the 3 S/C axes [U, V, W] coordinates should be specified.
In case of spin stabilized mode, the S/C pin axes [U, V, W] coordinates should be specified.

2.3.2. Sun position dependant orientation

ARIANE on-board flight program is able to perform any orientation in relation with the sun position at real separation time by assigning the launcher attitude to the actual lift-off time.

In case of 3-axis stabilized mode, the S/C axis to be related to the sun position should be specified. If desired, a second S/C axis can also be constrained to a specific position.
In case of spin stabilized mode, the S/C spin axis orientation with regards to sun position should be specified.
For other reference position than sun position, the Uers should contact Arianespace.

2.3.3. Adjustment

For specific multiple launch, Mission Analysis may lead Arianespace to request a slight adustment of the desired orientation.

2.4. Roll and Attitude Control System (SCAR/SCA) sequence

Any particular constraints on SCAR/SCA sequence, launcher commands required.

2.5. Sequence of events after separation until final orbit (for information only)

Describe main maneuvers from separation until final orbit including apogee firing schedule.

3. Spacecraft description

3.1. Spacecraft Systems of Axes

Include a sketch showing the spacecraft system of axes, the axes are noted Xs, Ys, Zs and form a right handed set (s for spacecraft).

3.2. Spacecraft geometry in the flight configuration

A drawing and a reproducible copy of the overall spacecraft geometry in flight configuration is required. It should indicate the exact locations of any equipment requiring access through shroud, lifting points locations and define the lifting device. Detailed dimensional data will be provided for the parts of the S/C closest to the "static envelope" under shroud (antenna reflectors, deployment mechanisms, solar array panels, thermal protections,...). Preferably, a 3D model (IGES extension) shall be supplied with the DUA.

3.3. Mass alignment inertia's (Nominal values and tolerances)

The data required is for the spacecraft after separation. If the adaptor is user supplied, also add spacecraft in launch configuration with adaptor and adaptor just after separation.

3.3.1. Range of major / minor inertia axis ratio

3.3.2. Dynamic out of balance (if applicable)

Indicate the maximum dynamic out of balance in degrees.

3.3.3. Angular momentum of rotating components

3.3.4. Table

Element (i.e. s/c adaptor)	Mass (kg)	C of G coordinates (mm)			Coefficients of inertia Matrix (kg. m2)					
		X_G	Y_G	Z_G	I_{xx}	I_{yy}	I_{zz}	I_{xy*}	I_{yz*}	I_{zx*}
Tolerances	(kg)	(mm)	(mm)	(mm)	mini maxi	mini maxi	mini maxi	mini maxi	mini maxi	mini maxi

<u>Notes:</u>

- C of G coordinates are given in spacecraft axes with origin of the axes at the separation plane.
- Inertia matrix is calculated in spacecraft axes with origin of the axes at the Center of gravity.
- The coefficients of the Inertia matrix must be given under 1 g conditions.

(*) The cross inertia terms must be intended as the opposite of the inertia products (Ixy = -Pxy).

3.3.5. Propellant / pressurant characteristics

TANKS			1	2	3	4
PROPELLANT			NTO	MMH	NTO	MMH
DENSITY		(kg/m^3)	1450	876	1450	876
TANK VOLUME		(l)				
FILL FACTOR		(%)				
LIQUID VOLUME		(l)				
LIQUID MASS		(kg)				
CENTER OF GRAVITY OF PROPELLANT LOADED TANK		Xs				
		Ys				
		Zs				
SLOSH MODEL Under TBD g	PENDULUM MASS	(kg)				
	PENDULUM LENGTH	(m)				
	PENDULUM ATTACHMENT POINT	Xs				
		Ys				
		Zs				
	FIXED MASS (if any)					
	FIXED MASS ATTACHMENT POINT (if any)	Xs				
		Ys				
		Zs				
	FUNDAMENTAL SLOSHING MODE NATURAL FREQUENCY (Hz)					

		PRESSURANT HELIUM			
TANKS		1	2	3	4
VOLUME	(l)				
LOADED MASS	(kg)				
CENTER OF GRAVITY (mm)	Xs				
	Ys				
	Zs				

3.4. Mechanical Interfaces

3.4.1. Spacecraft using Ariane supplied adaptor

3.4.1.1. Interface geometry

Provide a drawing with detailed dimensions and nominal tolerances showing:

Spacecraft interface ring and keyway, spring seats and supports, umbilical connectors location and supports, separation sensors (if any), equipment in close vicinity of separation clampband (super insulation, plume shields, thrusters).

3.4.1.2. Interface material description

For each spacecraft mating surface in contact with ARIANE adaptor and clampband, give: material, roughness, flatness, surface coating, rigidity (frame only), inertia and sufface (frame only).

3.4.2. S/C providing its own adaptor

Define adaptor and its interface with the launch vehicle (see specifications ST-0-P-19-01 and ST-0-P-19-02).

Define the characteristics of the separation system including:

1) Separation spring locations, type, diameter, free length, compressed length, spring constraint, energy.

2) Tolerances on the above.

3) Dispersion on spring energy vectors.

4) Dispersion of separation system.

5) Clampband tension.

6) Dispersion on pyro device actuation times.

3.4.3. Spacecraft accessibility requirements through shroud (fairing, SPELDA, SYLDA)

Indicate items on the spacecraft to which access is required through shroud and give their exact locations in spacecraft coordinates.

3.5. Electrical interfaces

3.5.1. Umbilical connectors(s) definition

3.5.2. Umbilical cable link between the spacecraft on tower and launch center and the spacecraft blockhouse console or COTE located in the launch center, the payload room CMCU, or the launch table, respectively.

Indicate voltage and current during launch preparation and also at POE extraction in the following tables.

Launch preparation

S/C connector pin allocation number	Function	Max voltage (V)	Max current (mA)	Max voltage drop (ΔV)	OR	Expected one way resistance (Ω)

<u>POE extraction</u> (Lift-Off)

Function	Max voltage (V)	Max current (mA)

3.5.3. Description of components, inserted mast junction box (if used)

Mechanical interface: max dimensions TBD.
Electrical interface: power: 1 kVA, 50 or 60 Hz.

3.5.4. Block diagram showing lines functions on spacecraft side and blockhouse side

3.5.5. Data links requirements (baseband and data network) between spacecraft and check-out system

3.5.6. Description of additional links, used after spacecraft erection on launch vehicle, for test or ground operations

3.5.7. Spacecraft earth potential reference point location on spacecraft interface frame

3.6. Radioelectrical interfaces

3.6.1. Radio link requirements and disruption between spacecraft, launch center, spacecraft check-out system and preparation buildings S1, S3

3.6.2. Antenna(e) diagrams and directivity

Include transmit and receive points location of antenna(e) to be considered for radio links during launch preparation.

3.6.3. Spacecraft transmit and receive systems

3.6.3.1. Description of spacecraft telemetry and telecommand systems

3.6.3.2. Description of payload telecommunications system (for information only)

3.6.3.3. System characteristics

3.6.3.3.1 On board system

For each TM and TC and system used on the ground and during launch, give the following:

SOURCE UNIT DESIGNATION		S1	S2	S...
Function				
Band				
Carrier Frequency, F_0 (MHz)				
Bandwidth centered Around F_0	-3 dB			
	-60 dB			
Carrier Modulation	Type			
	Index			
Carrier Polarization				
Local Oscillator Frequencies				
1st intermediate Frequency				
2nd intermediate Frequency				
EIRP, transmit (dbm)	Max			
	Nom			
	Min			
Field strength at antenna, receive (dbµ V/M)	Max			
	Nom			
	Min			
Antenna	Designation Location Gain Pattern			

3.6.3.3.2. Satellite ground station network

For each group station to be used for acquisition and GTO operations (nominal and back-up stations) please indicate the geographical location (latitude and longitude) and the radio-electrical horizon.

3.6.3.4. Spacecraft transmission plan

Source	Function	During preparation on launch pad	After H0-1h30 until 20s after separation	In transfer orbit	On station
S1					
S2					
S...					

3.7 Environmental characteristics

3.7.1 Fundamental modes (lateral, longitudinal) of spacecraft hardmounted at interface

3.7.2 Thermal characteristics during launch preparation and boost phase including thermal limits

3.7.3 Dissipated power during countdown and boost phase

3.7.4. Contamination characteristics and constraints

4. Operational requirements

4.1. Provisional range operations schedule

Include the definition of CCU interface and of the spacecraft lifting device

4.2 Spacecraft Preparation in building S1 (if applicable)

4.2.1 Main operations list and description

4.2.2 Power requirements

Indicate Voltage, Amps, # phases, frequency, category (standard or no break).

4.2.3 Facility equipment requirements

4.2.4 RF and hardline links requirements

4.2.5 Telecommunications requirements

Telephone, Facsimile, Data lines, Time code, Telex...

4.2.6 Miscellaneous

4.3 Solid Motor and pyro equipment preparation in building S2 (if applicable)

4.3.1 Main operations list and description

4.3.2 Power requirements

Indicate Voltage, Amps, # phases, frequency, category (standard or no break).

4.3.3 Facility equipment requirements

4.3.4 Miscellaneous

4.4 SPM X-Ray in building S4 (if applicable)

4.4.1 SPM description

4.4.2 GSE description

4.4.3 Facility equipment requirements (cold soak, films...)

4.5 Spacecraft fillinq and assembly in building S3

4.5.1 Main operations list and description

4.5.2 Power requirements

Indicate Voltage, Amps, # phases, frequency, category (standard or no break).

4.5.3 Facility equipment requirements

4.5.4 RF and hardline link requirements

4.5.5 Miscellaneous

4.6 Spacecraft preparation at servicing tower

4.6.1 Main operation list and description

4.6.2 Power requirements

Indicate Voltage, Amps, Frequency.

4.6.3 Facility equipment requirements

4.6.4 Miscellaneous

4.7. Transportation requirements

Give also dimensions and weights of any non standard container.

4.8 Hazardous items storage requirements

4.8.1 Propellants

4.8.2 Pyrotechnic devices

4.9 Fluids and propellants requirements

4.9.1 List of fluids

Indicate type, quality, quantity and location for use of fluids to be supplied by AE.

4.9.2 Chemical and physical analysis to be performed at the range

Indicate for each analysis: type and specification.

4.9.3 Safety garments needed for propellants loading

Indicate number and type.

5. General

5.1. Estimated packing list (including heavy and large container characteristics)

Indicate designation, number, size (L x W x H in m) and mass (kg).

5.2. Technical support requirements

Workshop, instrument calibration.

5.3 Hotel and cars reservations

Estimate number of hotel rooms and rental cars required for the campaign.

5.4. Miscellaneous services

6. Spacecraft development plan

7. Tests

7.1. Spacecraft test plan (vibration, acoustic, shocks...)

Define the qualifcation policy, qualification (protoflight or qualification model).

7.2. Requirements for test equipment (ACU's, clampband volume simulator...)

7.3. Tests on the user's premises

7.4. Tests at the range

8. Definitions, acronyms, symbols

ANNEX Safety Submission Phase 1

The User prepares a file containing all the documents necessary to inform CSG of his plans with respect to hazardous systems. This file contains a description of the hazardous systems. It responds to all questions on the hazardous items check list given in the document CSG Safety Regulations V2F3, and summarized here below.

1. Electro-pyrotechnic devices

1.1. Category-A initiators (for operations which could be hazardous for personnel and/or equipment)

1.2. Category-B igniters(for operations which are not hazardous)

1.3. Location

1.4. Function

1.5. Type and manufacturer

1.6. Production serial number

1.7. Bridge resistance

1.8 No-fire current

1.9 All fire current

1.10. Firing current

1.11. Selected firing current

1.12. Checkout current

1.13. Probabilities associated to those currents and confidence level

1.14. Time required for installation on spacecraft

1.15. Location in spacecraft

1.16. Radio-sensitivity characteristics

1.17. Electrostatic sensitivity characteristics

1.8. Electrical initiation and control circuits

2. Solid propellant motors

2.1. International classification

2.2. Manufacturer and references

2.3. Previous use

2.4. Description (structure, weight, nature of propellant)

2.5. Ignition system

2.6. Firing and monitoring circuit

2.7. Storage and transfer containers

2.8. Associated ground support equipment

3. Liquid Propellants

3.1. Does the payload and/or associated ground equipment contain hazardous fluids. If so, indicate quantities and specifications

3.2. Description of the propulsion system

3.3. Location and operation procedures

4. Pressure vessels

4.2. Nature of fluids - Pressure

4.3. Tanks: type and manufacturer, structure, safety factor, qualification and acceptance tests

4.4. Associated ground support equipment

5. Batteries

5.1. Type of batteries - Description

5.2. Do they contain hazardous fluids ?

5.3. Charge

6. Radiation

6.1. Non-ionising radiations

- Antennas: locations, direction and characteristics.
- Radiation power, spectrum of frequencies, schedules and places of emission.
- Safety devices.

6.2 Ionising radiations

- Do the spacecraft or associated ground equipment transmit ionising radiations?
- Kind of radiation, activity, forseeable exposition, venting (radioactive gas).
- Operations and safety regulations.

7. Interface (if not provided by the launcher authority)

7.1 Mechanical interfaces:

- Detailed description of the mechanical interface between the launcher and the payload (separation system).

- Detailed description of the mechanical and/or pneumatic between the launch tower and the payload.

7.2 Electrical interfaces

- Detailed description of the electrical interface between the launcher (adaptor) and the payload; separation devices, monitoring means, safety devices (separation switches).

- Detailed description of the electrical interface between the launch tower and the payload:
  - Preparation and test equipment
  - Operations (arming, battery charge,)
  - List of voltages and currents on the umbilical cable conductors at the moment of plug release

7.3 Umbilicals

- Type and number
- Fixation and extraction methods

8. Miscellaneous

8.1 Are the CSG Safety Regulations complied with?

8.2 Is any waiver requested?

8.3 Other safety problems not so far dealt with

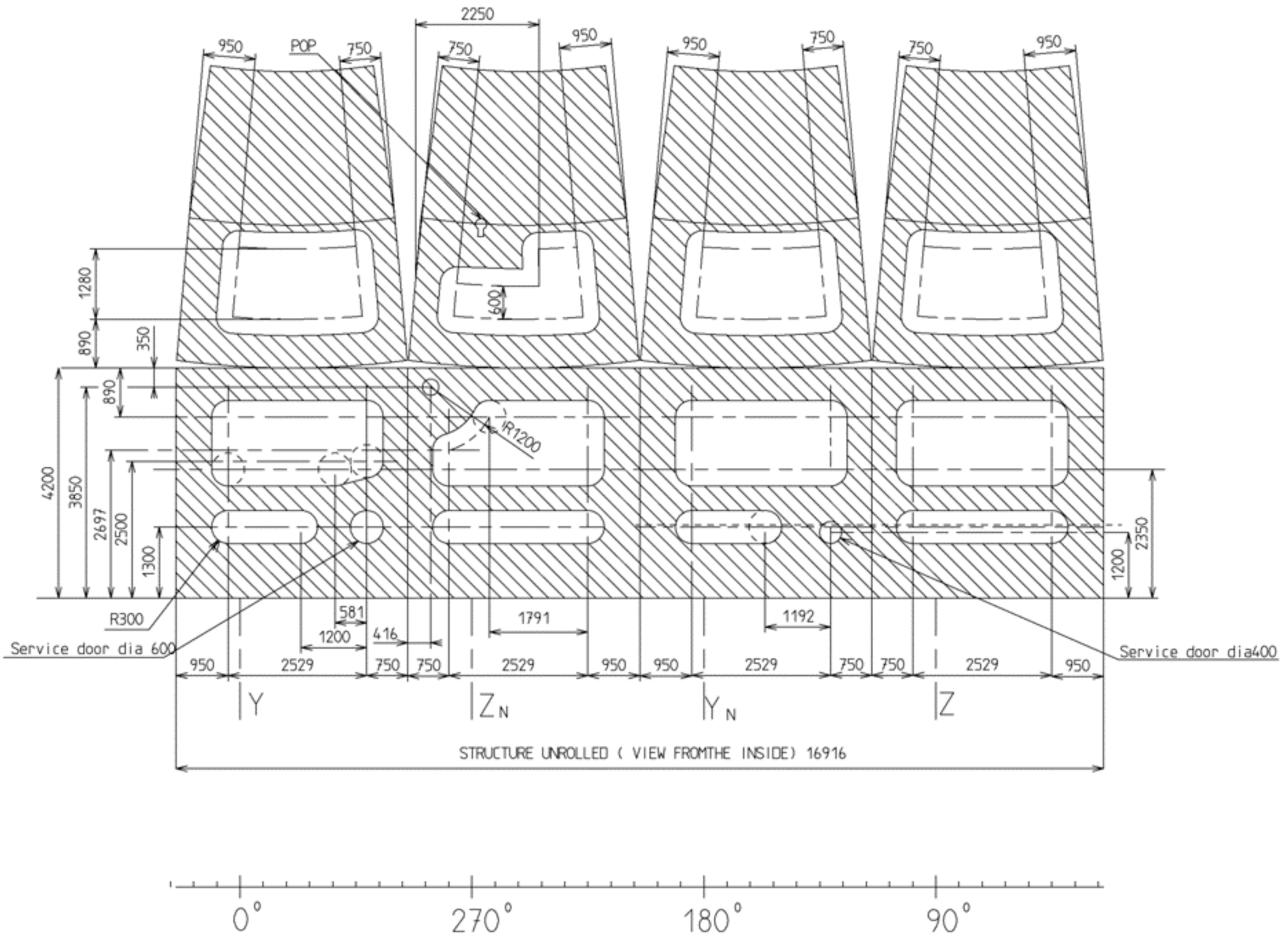
Spacecraft accessibility — Annex 4

Figures A4-1 to A4-6 show a projection of the interior of the fairing and SYLDA 5 and SPELTRA. They show which areas are authorized, subject to negotiation, or prohibited for the location of access doors. The standard version includes two access doors per spacecraft with an effective aperture 600 mm wide.

The distance between the centres of the circumscribed circles of two adjacent apertures must be greater than the sum of the diameters of these circles.

The position of the apertures required in the SYLDA 5 will be optimised to align with the fairing doors.

Any request for apertures outside the above limits will be subject to a special feasibility study.



FORBIDDEN AREA FOR PAYLOAD ACCESS DOORS & RADIO TRANSPARENT WINDOWS

MINIMUM DISTANCE BETWEEN TWO DOOR CENTRES OR DOOR-RT WINDOW 1200

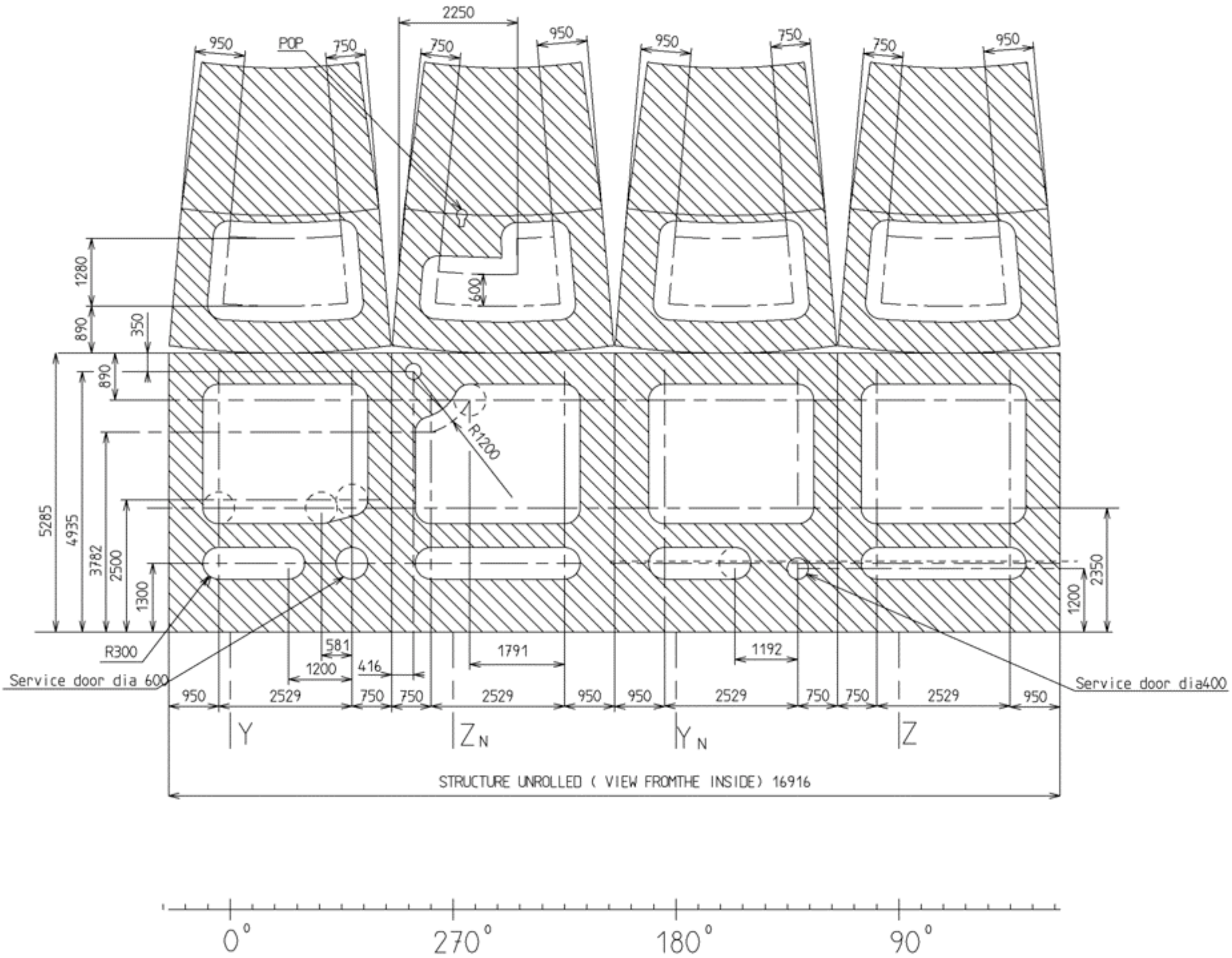
MINIMUM DISTANCE BETWEEN TWO RT-WINDOW 650

ACCESS DOOR SHAPE : DIA. 600

RADIO TRANSPARENT WINDOW SHAPE : DIA. 250

Z/Y ARE LAUNCHER AXIS

Fig. A4-1 - Short fairing access doors and R/F windows locations and dimensions



FORBIDDEN AREA FOR PAYLOAD ACCESS DOORS & RADIO TRANSPARENT WINDOWS

MINIMUM DISTANCE BETWEEN TWO DOOR CENTRES OR DOOR-RT WINDOW 1200

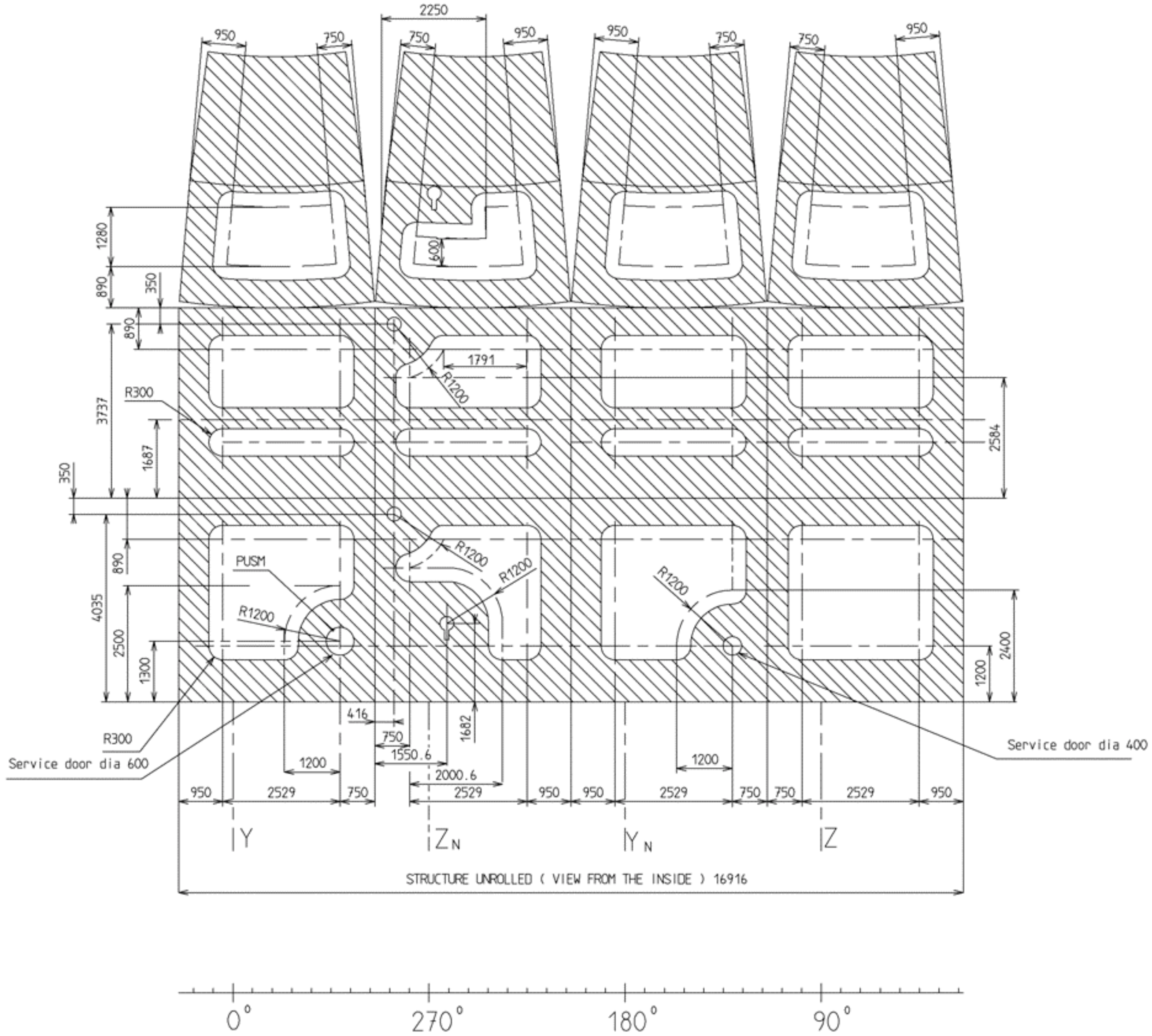
MINIMUM DISTANCE BETWEEN TWO RT-WINDOW 650

ACCESS DOOR SHAPE : DIA. 600

RADIO TRANSPARENT WINDOW SHAPE : DIA. 250

Z/Y ARE LAUNCHER AXIS

Fig. A4-2 - Medium fairing access doors and R/F windows locations and dimensions



FORBIDDEN AREA FOR PAYLOAD ACCESS DOORS & RADIO TRANSPARENT WINDOWS

MINIMUM DISTANCE BETWEEN TWO DOOR CENTRES OR DOOR-RT WINDOW 1200

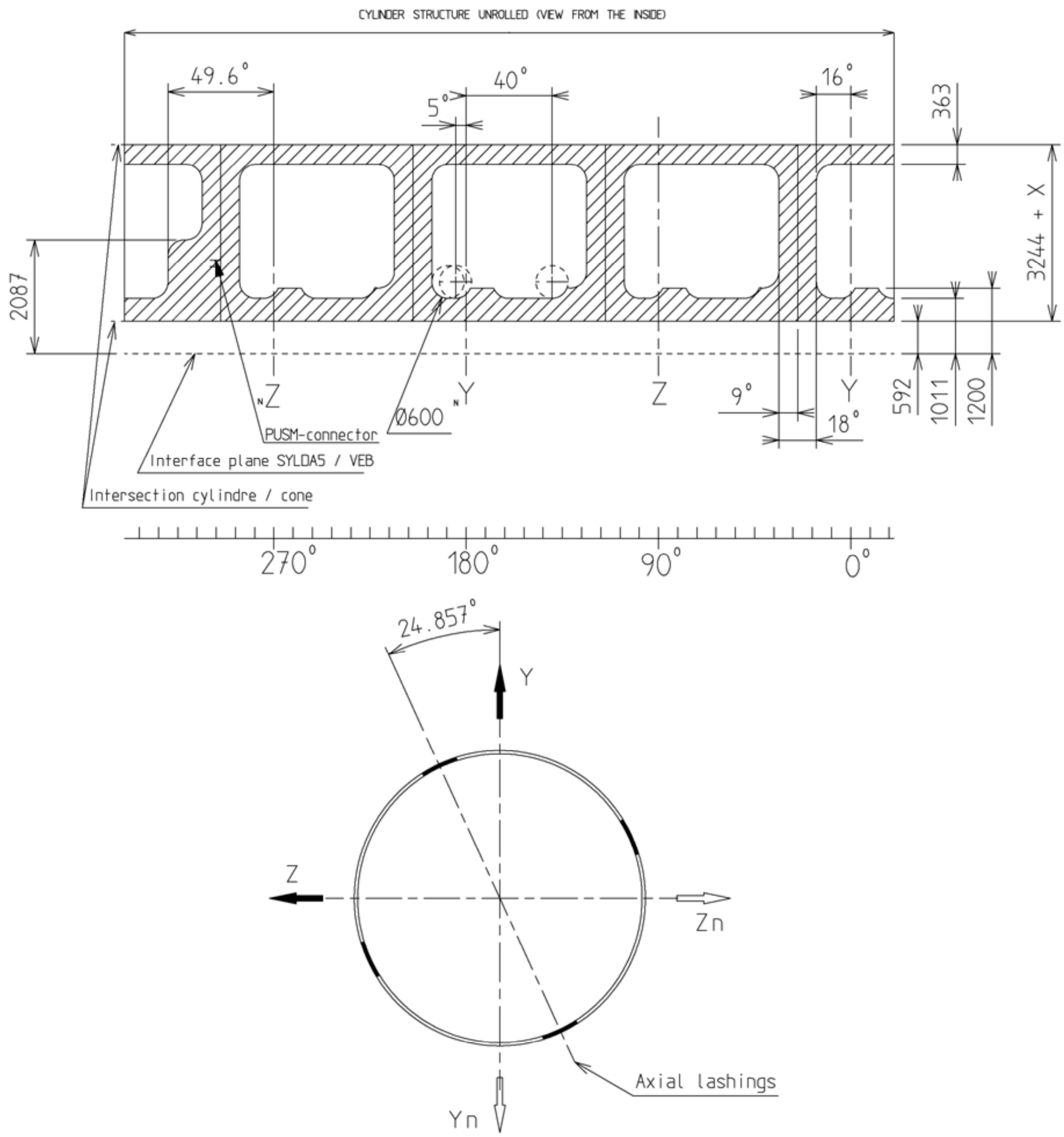
MINIMUM DISTANCE BETWEEN TWO RT-WINDOW 650

ACCESS DOOR SHAPE : DIA. 600

RADIO TRANSPARENT WINDOW SHAPE : DIA. 250

Z/Y ARE LAUNCHER AXIS

Fig. A4-3 - Long fairing access doors and R/F windows locations and dimensions



PAYLOAD ACCESSIBILITY ON OTHER VERSIONS OF SYLDA 5 IS PROPORTIONALLY EXTENDED WITH RESPECT TO THE CORRESPONDING HEIGHT

(X = 0,300,600,900,1200,1500)

FORBIDDEN AREAS FOR PAYLOAD ACCESS HOLES

ACCESS HOLE SHAPE : DIA 600 mm

Fig. A4-4 - SYLDA 5 access holes locations and dimensions

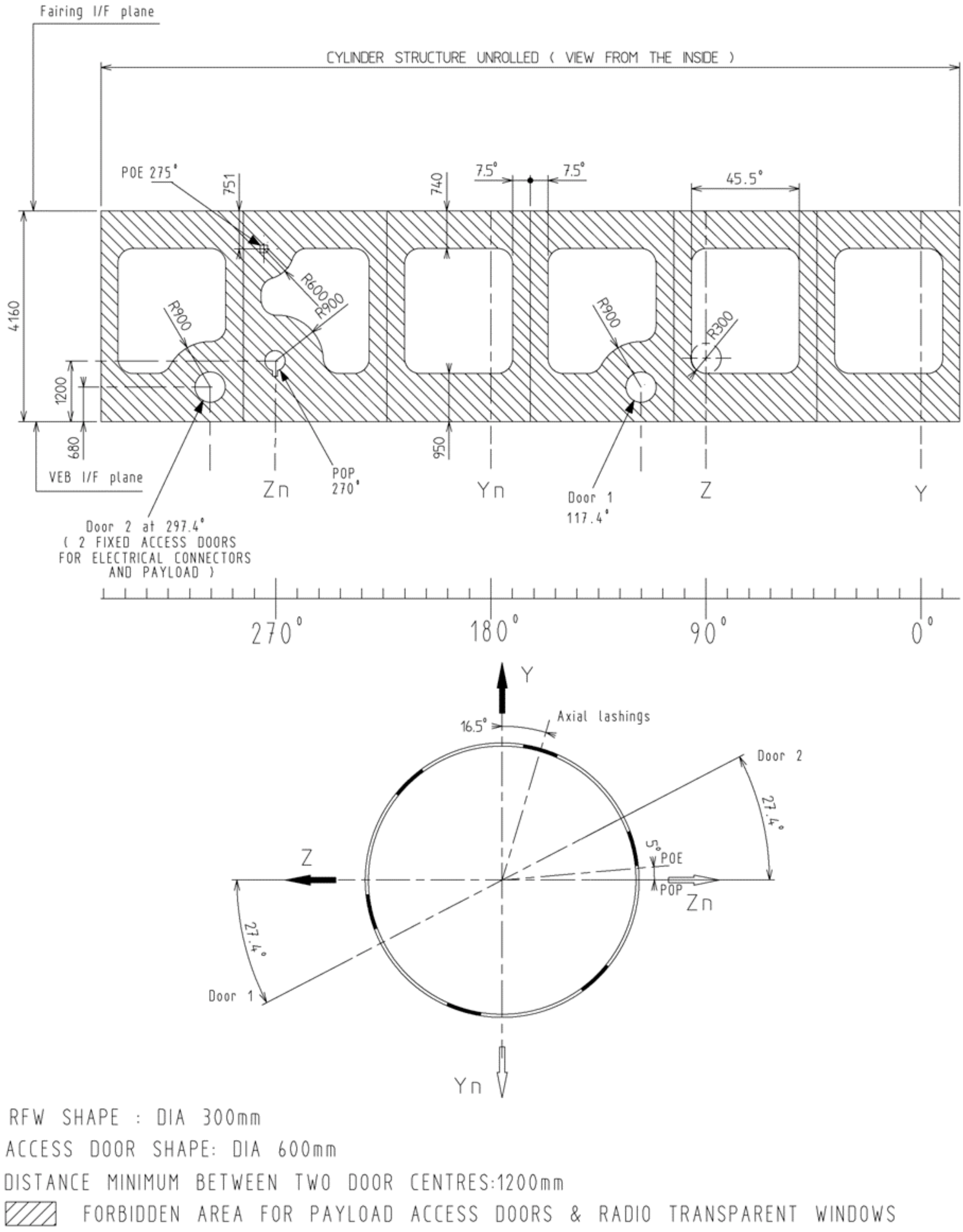
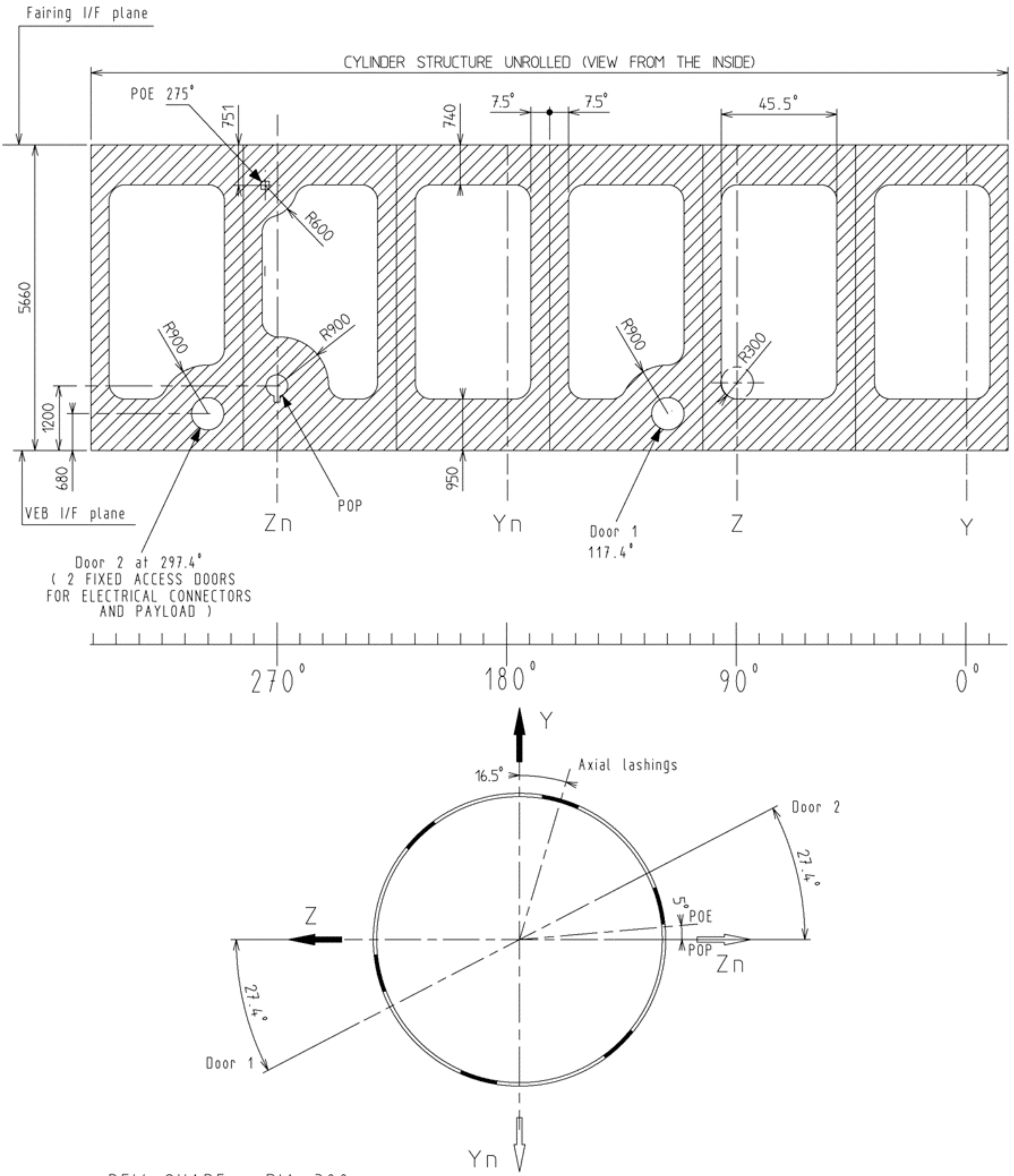


Fig. A4-5 - SPELTRA 4160 access doors and R/F windows locations and dimensions



RFW SHAPE : DIA 300mm

ACCESS DOOR SHAPE: DIA 600mm

DISTANCE MINIMUM BETWEEN TWO DOOR CENTRES:1200mm

FORBIDDEN AREA FOR PAYLOAD ACCESS DOORS & RADIO TRANSPARENT WINDOWS

Fig. A4-6 - SPELTRA 5660 access doors and R/F windows locations and dimensions

Usable volume under Fairing, SPELTRA and SYLDA 5 — Annex 5

Usable volume

The free volume available to the payload, known as the "static volume", is shown in the figures A5-1 to A5-3.

This volume constitutes the limits that the static dimensions of the spacecraft, including manufacturing tolerance, thermal protection installation, appendices..., may not exceed.

It has been established having regard to the frequency requirements of paragraph 4.5.4. Allowance has been made for the flexibility of SPELTRA, fairing, SYLDA 5 and of the spacecraft.

The compatibility of the critical dimensions with the usable volume will be studied in greater depth by coupled load analysis, based on detailed informations provided by the User.

Note : ∅ 5400 mm extension structures (ACY 5400) allow to adapt the existing fairing, SPELTRA or SYLDA 5 to the Customer need (see chapter 1).

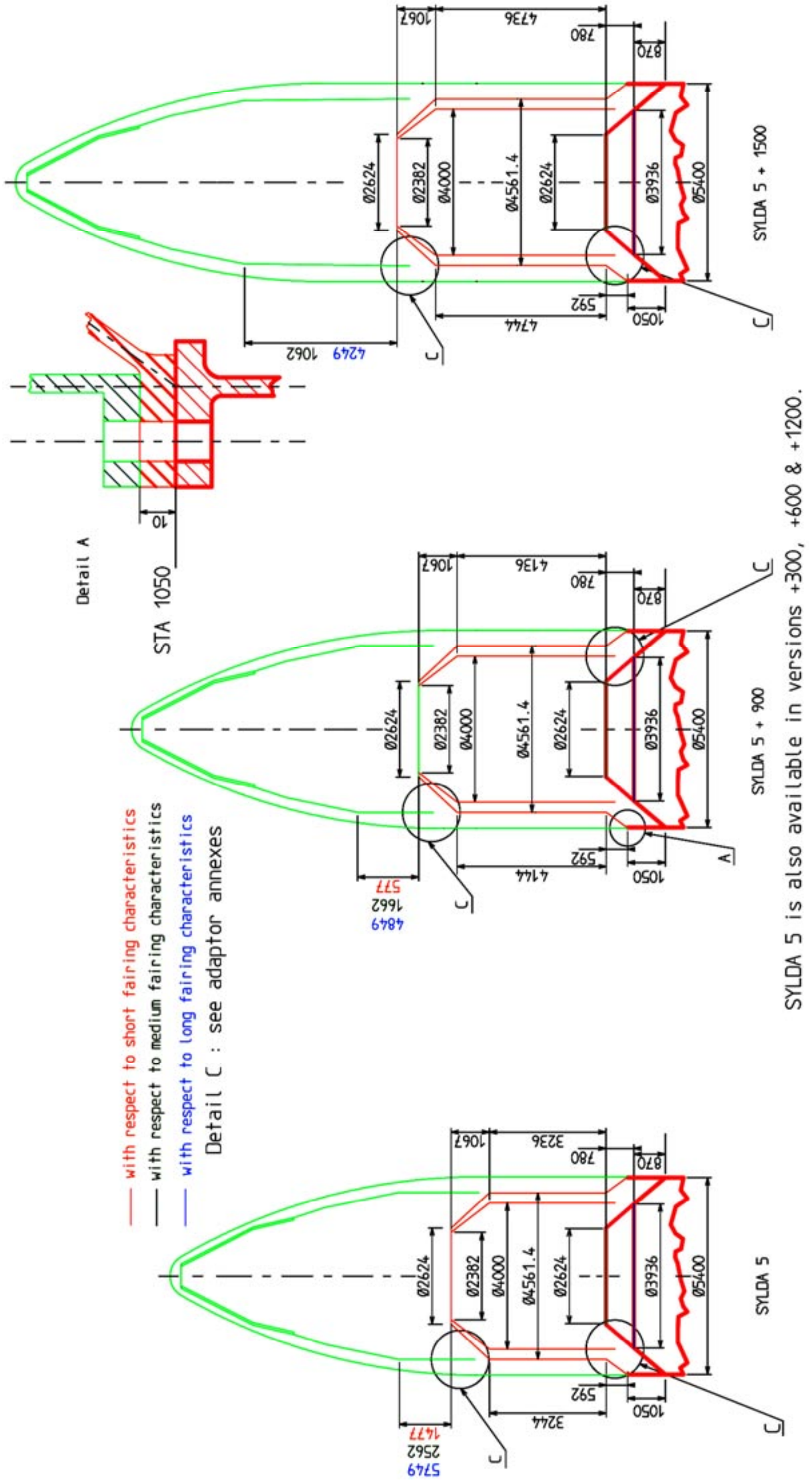


Fig. A5-1 – Usable volume beneath payload fairings and SYLDA 5

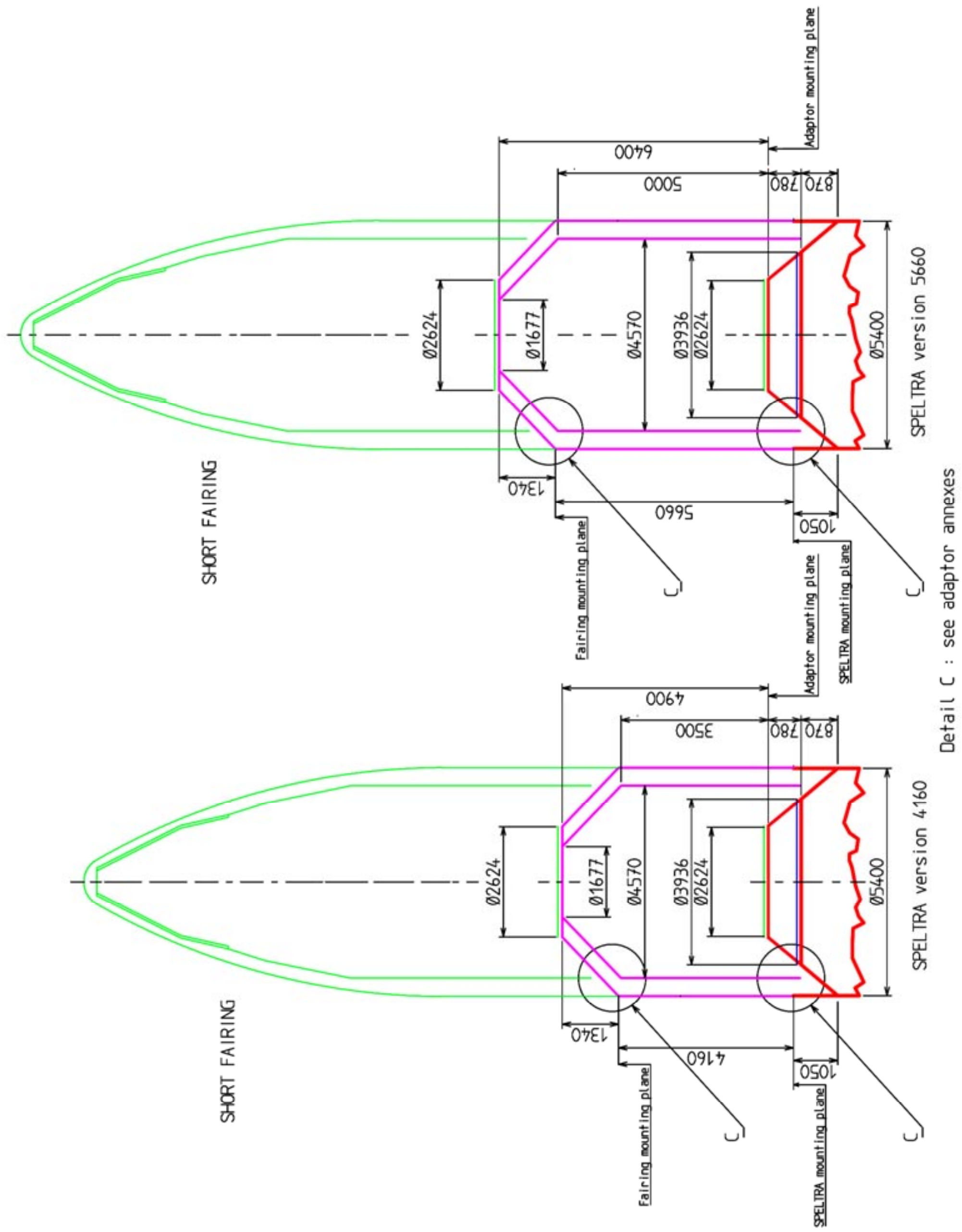


Fig. A5-2 – Usable volume beneath SPELTRA

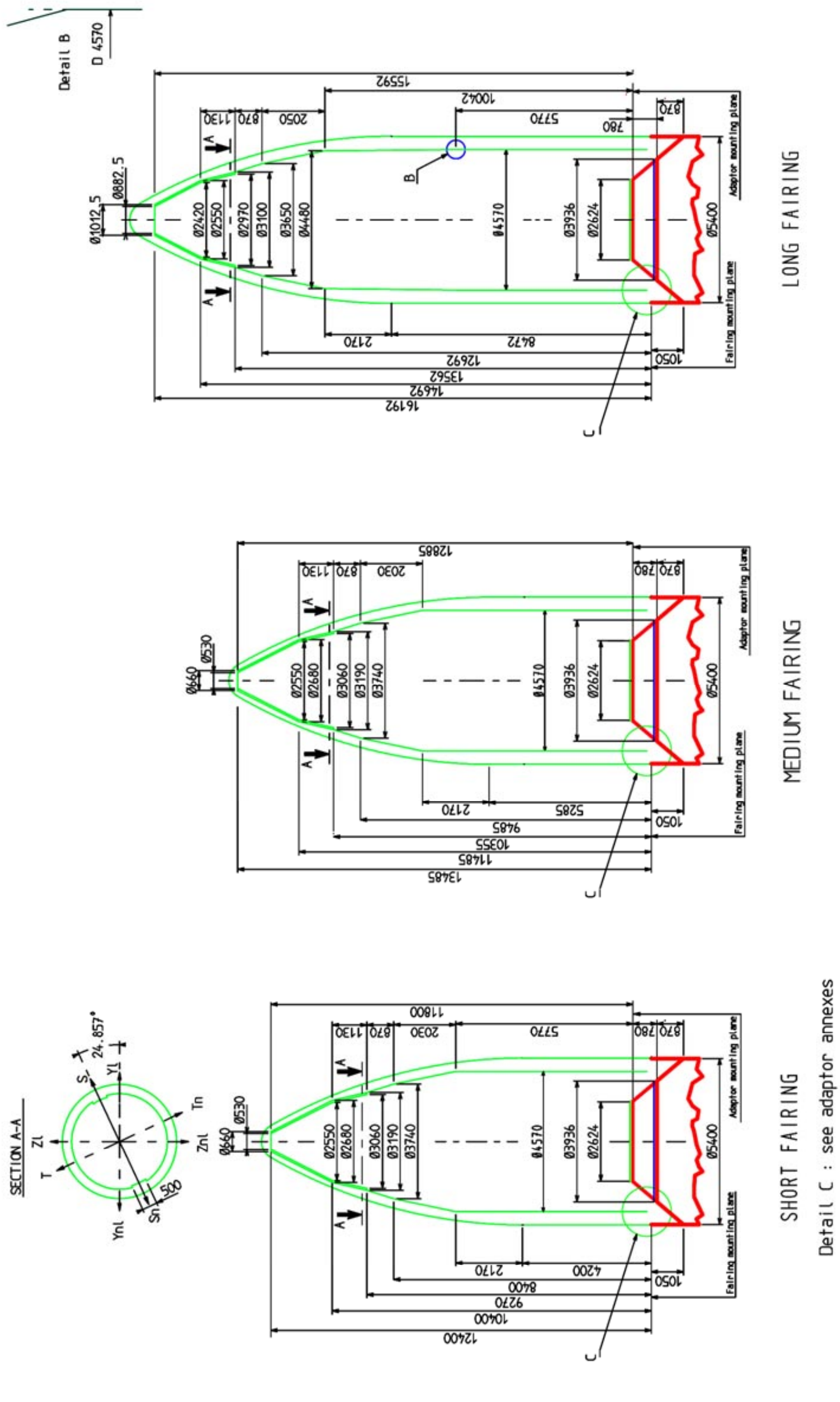


Fig. A5-3 – Usable volume beneath payload farings

Adaptor 937V5 — Annex 6

This 937V5 adaptor is a carbon fibre structure in the form of a truncated cone, with a diameter of 937 mm at the level of the spacecraft separation plane. It is attached to the reference plane (∅ 2624) by a bolted connector frame, and also provides for spacecraft separation.

This 937V5 adaptor has a mass of 140 kg.

The actual spacecraft pair of values (Mcu, X_G) must remain within admissible limits as defined in figure A6-1 using quasi-static load values indicated in paragraph 4.5.5 (chapter 4).

The spacecraft is secured to the adaptor interface frame by a clampband. This comprises a metal strip applying a series of clamps to the payload and adaptor frames. The clampband assembly comprises two half clampbands, connected by bolts which are cut pyrotechnically to release the clampband, which is then held captive by the adaptor assembly.

The clampband tension does not exceed 22 000 N at any time, it is defined to ensure no gapping between the spacecraft and adaptor interface frames in ground and flight environment.

The spacecraft is forced away from the launch vehicle by 4 springs integral with the adaptor and bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.
The force exerted on the spacecraft by each spring does not exceed: 900 N.

Adaptors are equipped either with external or internal springs on user request.

Two microswitches used to detect separation are located inside spring guides (see Fig. A6-6).

The adaptor assembly can provide bearing faces for the S/C microswitches aligned on the spring centre lines.

Umbilical connectors brackets: on the spacecraft side, the connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

Note: The adaptor cone is made of two parts: the cone itself and the upper frame. In order to ease the clampband installation, the upper frame can be dismantled from the cone. Mating of the spacecraft is, in that case, performed in two steps: clampband installation, and then bolting of the spacecraft and adaptor upper frame to the cone. To perform this operation, a stiffening tool is used which reduced the diameter of the inner usable volume to 370 mm (see Figure A6-8).

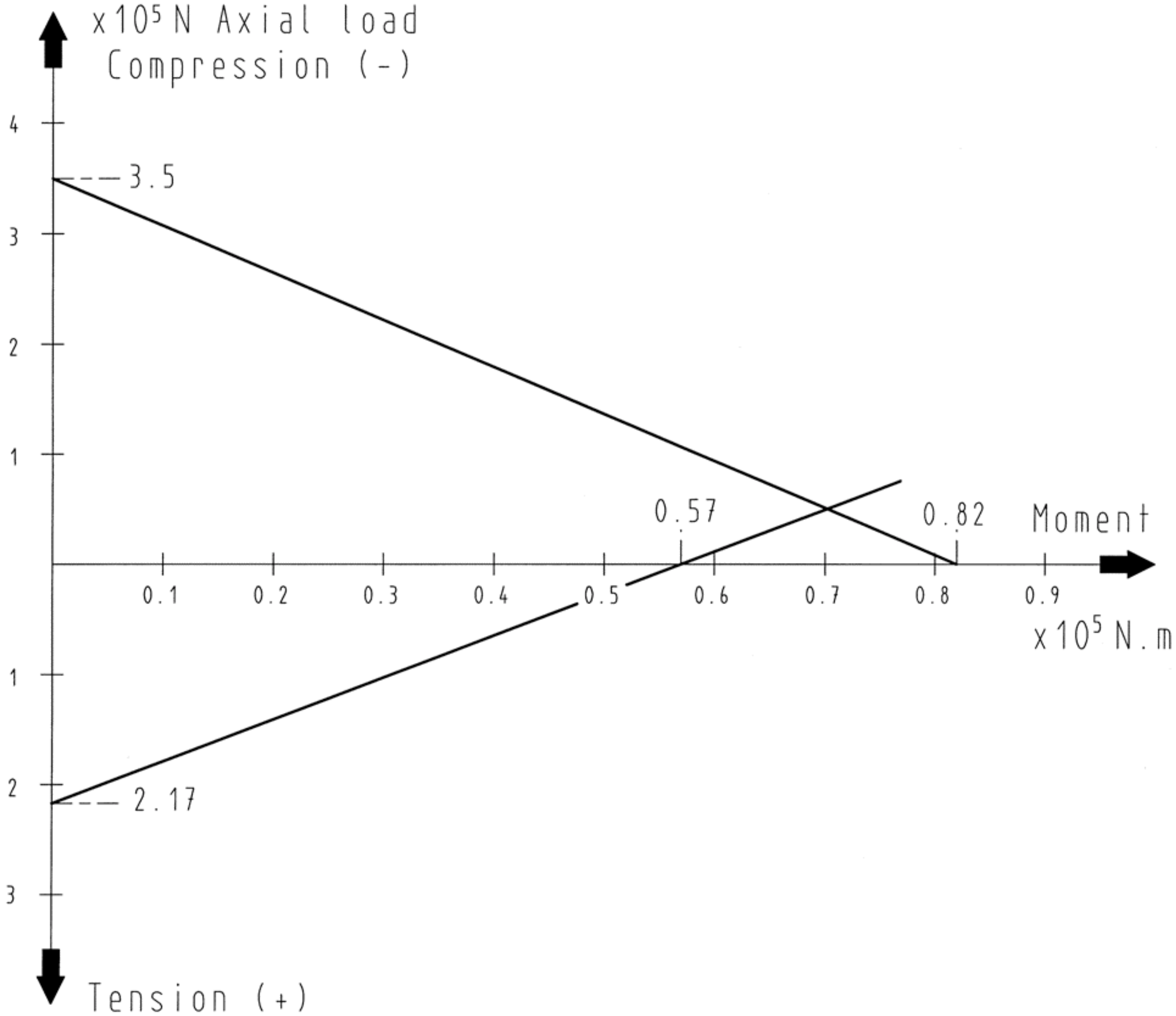


Fig. A6-1 – Limit loads of adaptor 937V5 at separation plane

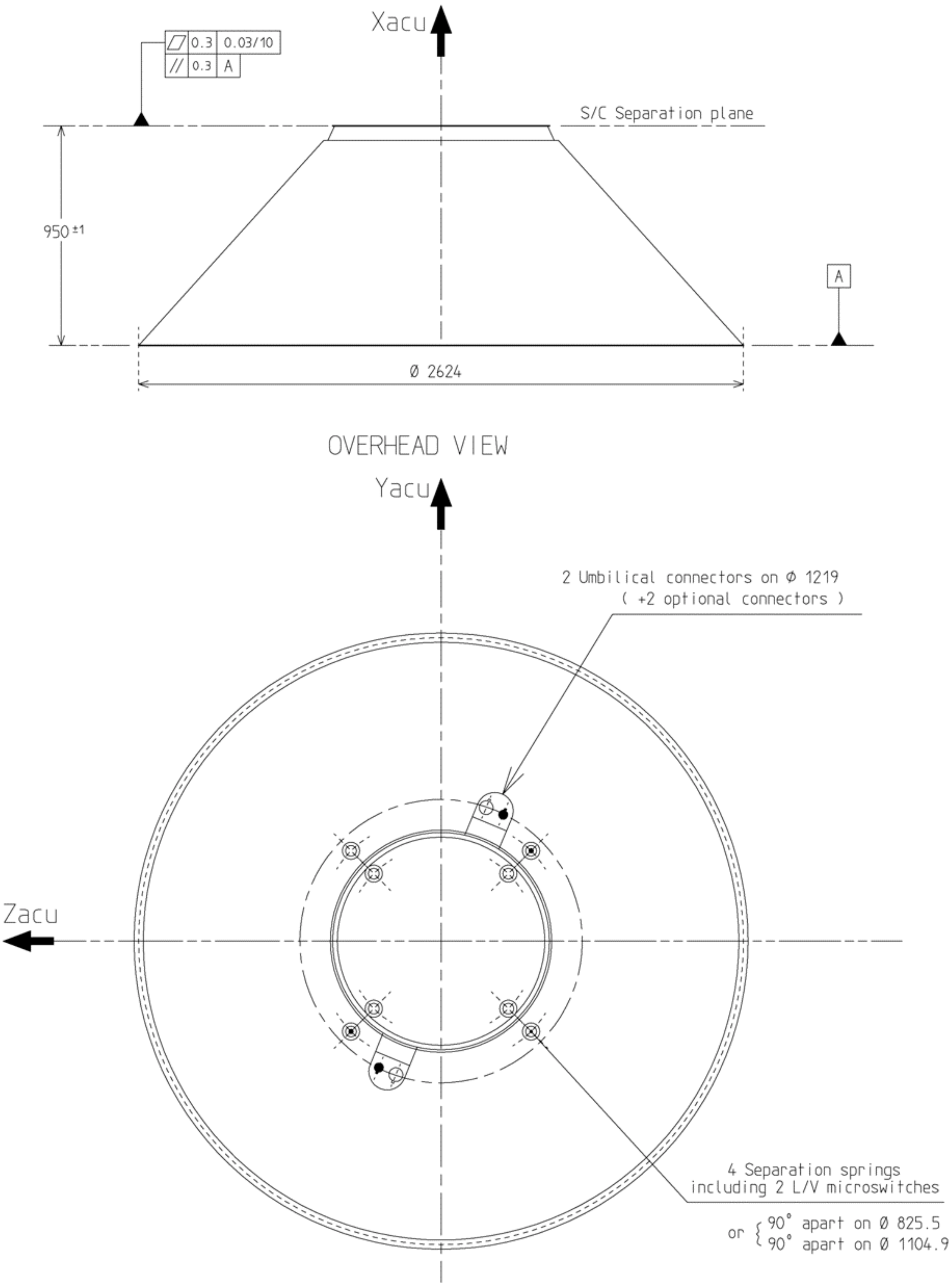


Fig. A6-2 – Adaptor 937V5
General view and main characteristics

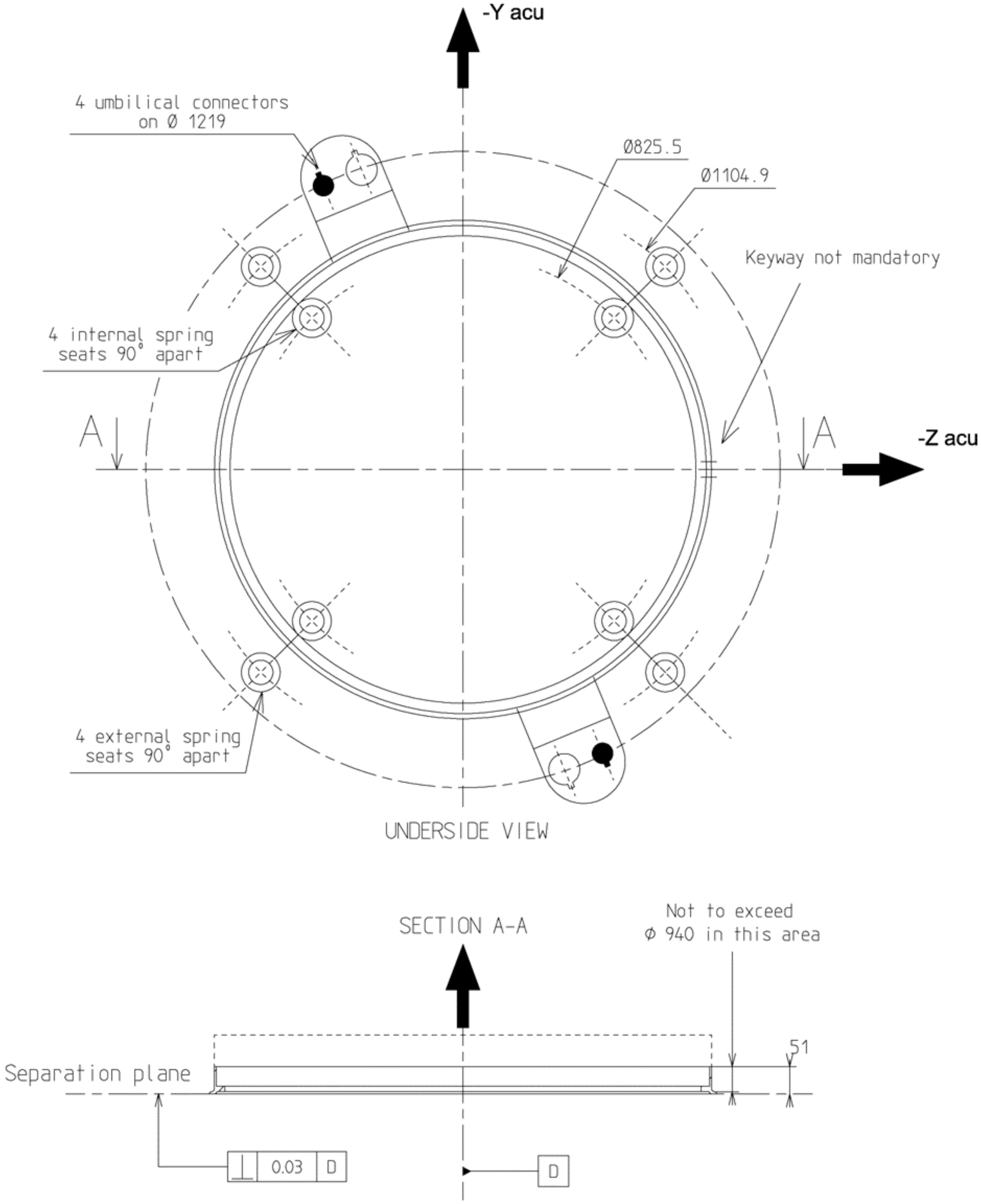


Fig. A6-3 – Adaptor 937V5
Spacecraft configuration view and main characteristics

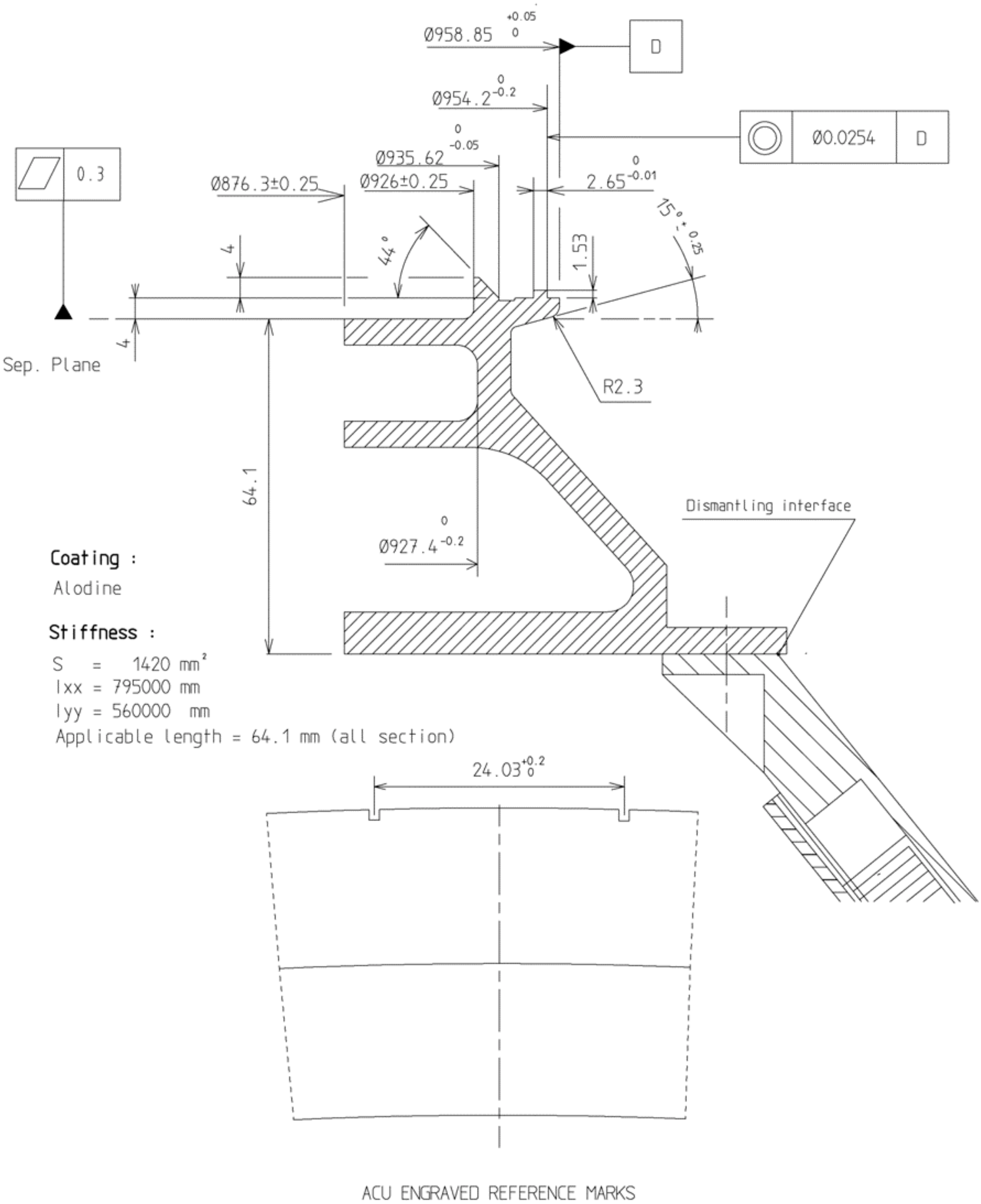
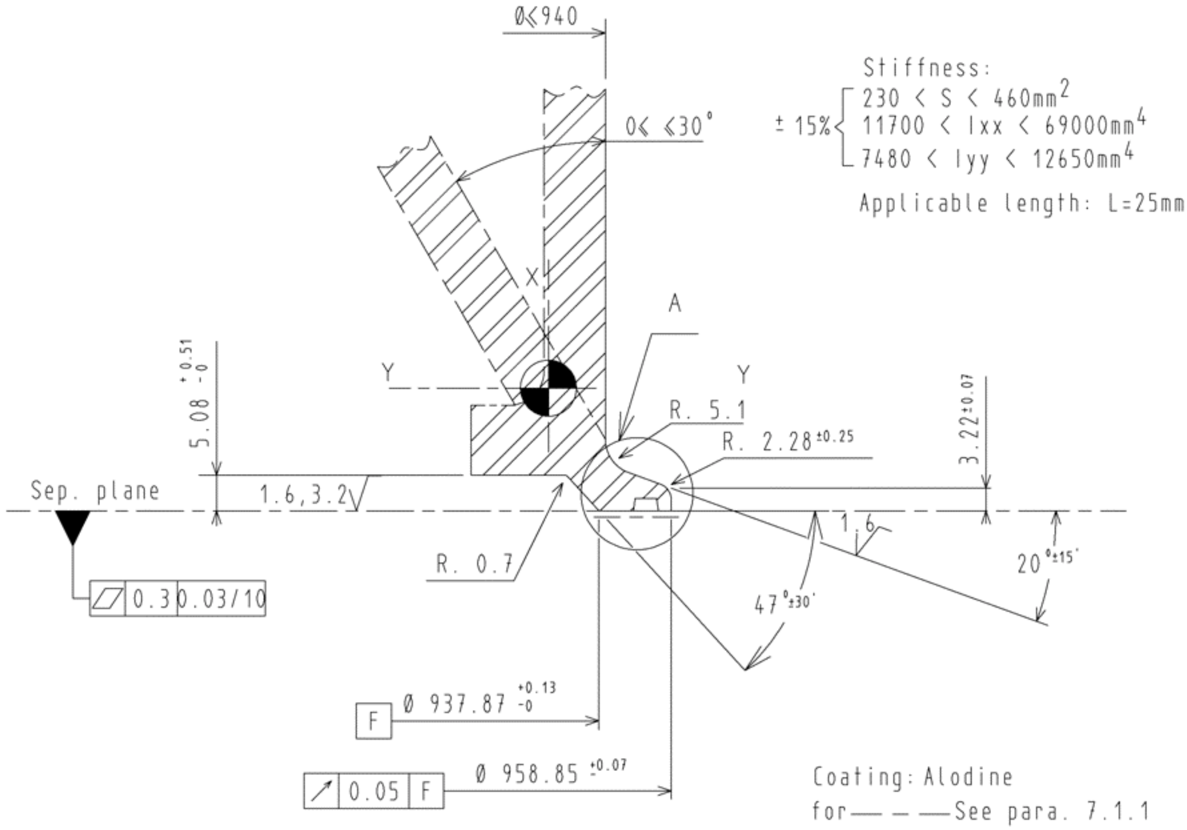
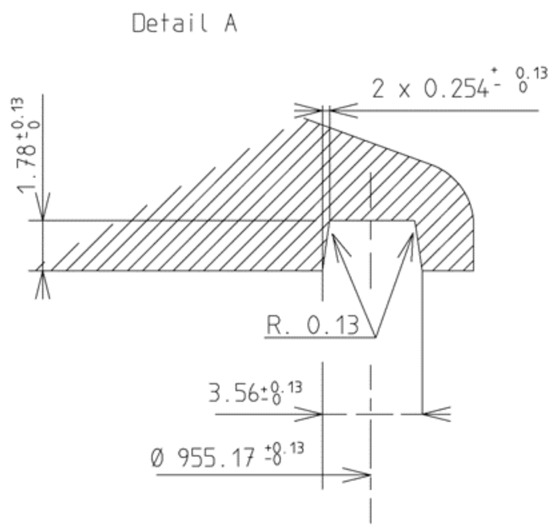


Fig. A6-4 – Adaptor 937V5
Forward frame





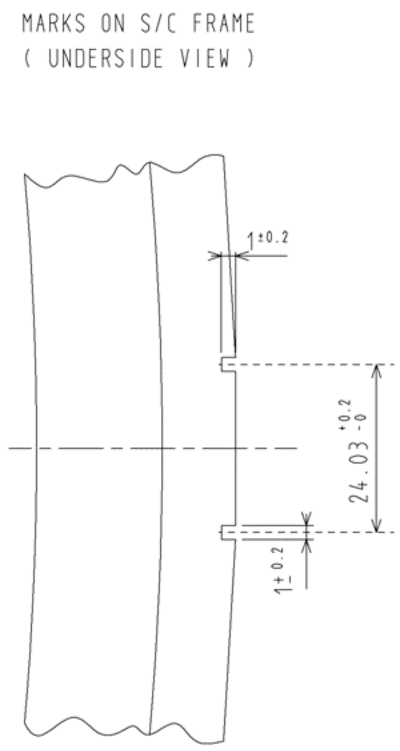


Fig. A6-5 – Adaptor 937V5
Spacecraft interface frame (details)

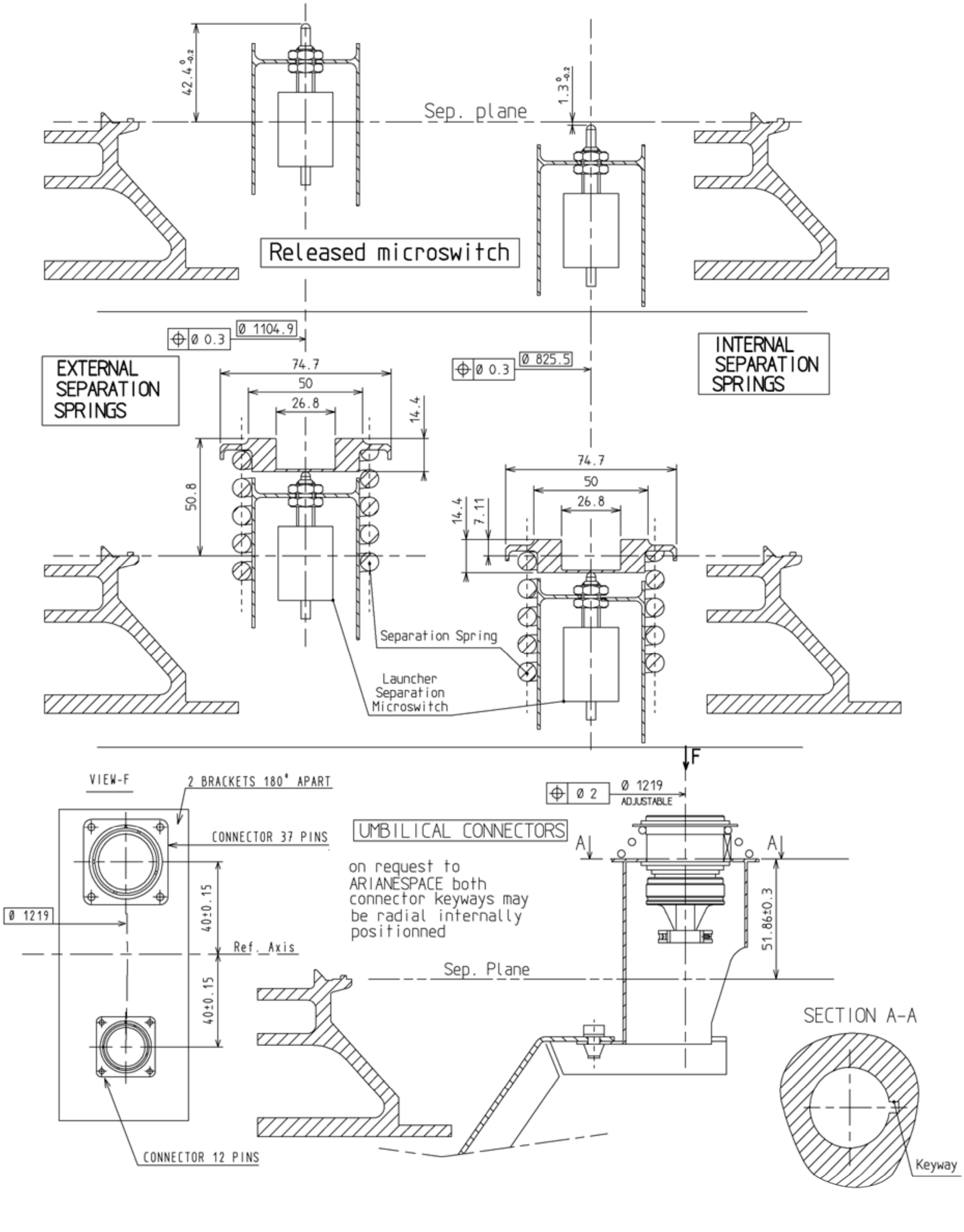


Fig. A6-6 – Adaptor 937V5
Adaptor mechanical interfaces (details)

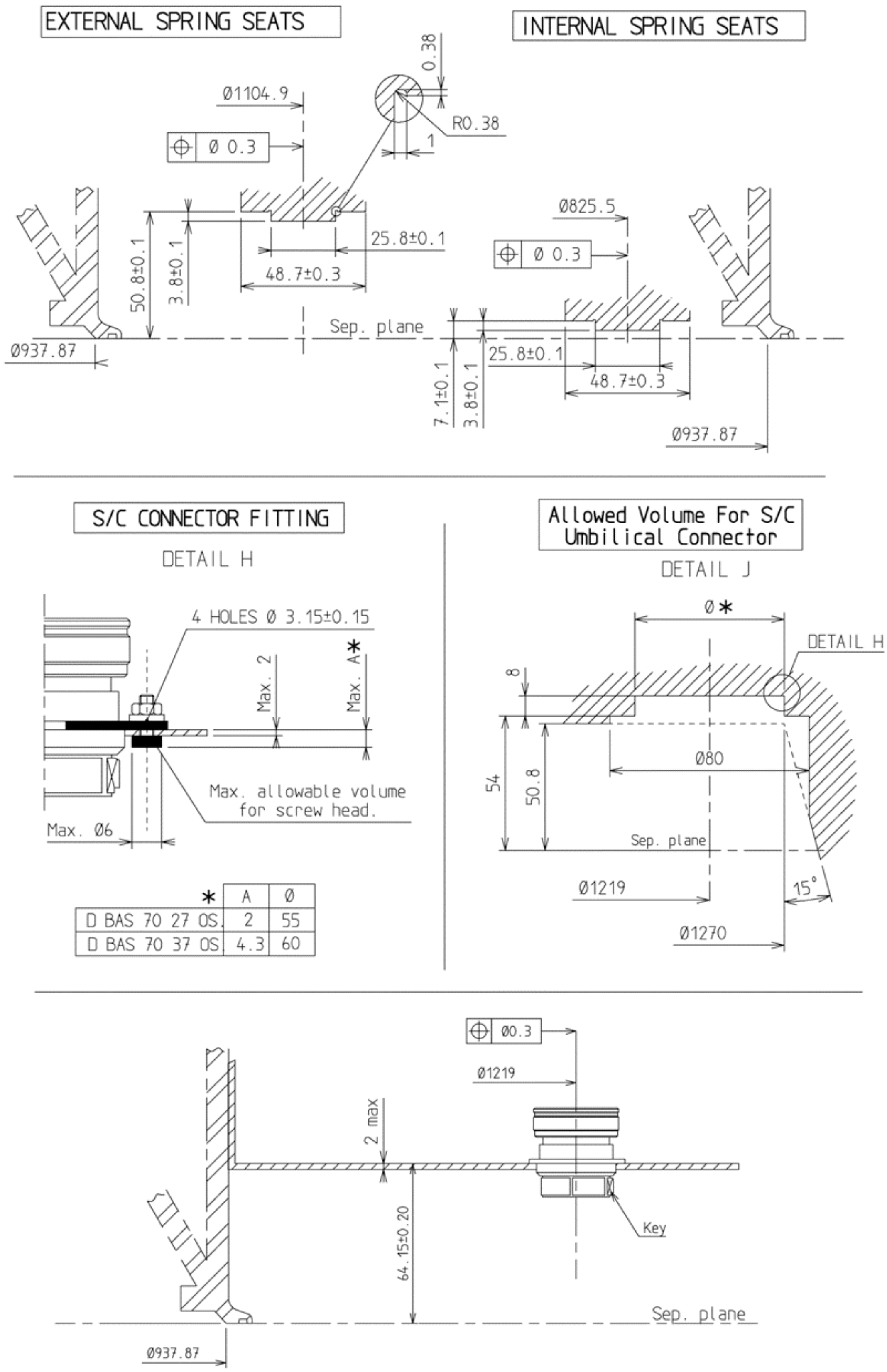


Fig. A6-7 – Adaptor 937V5
Spacecraft mechanical interfaces (details)

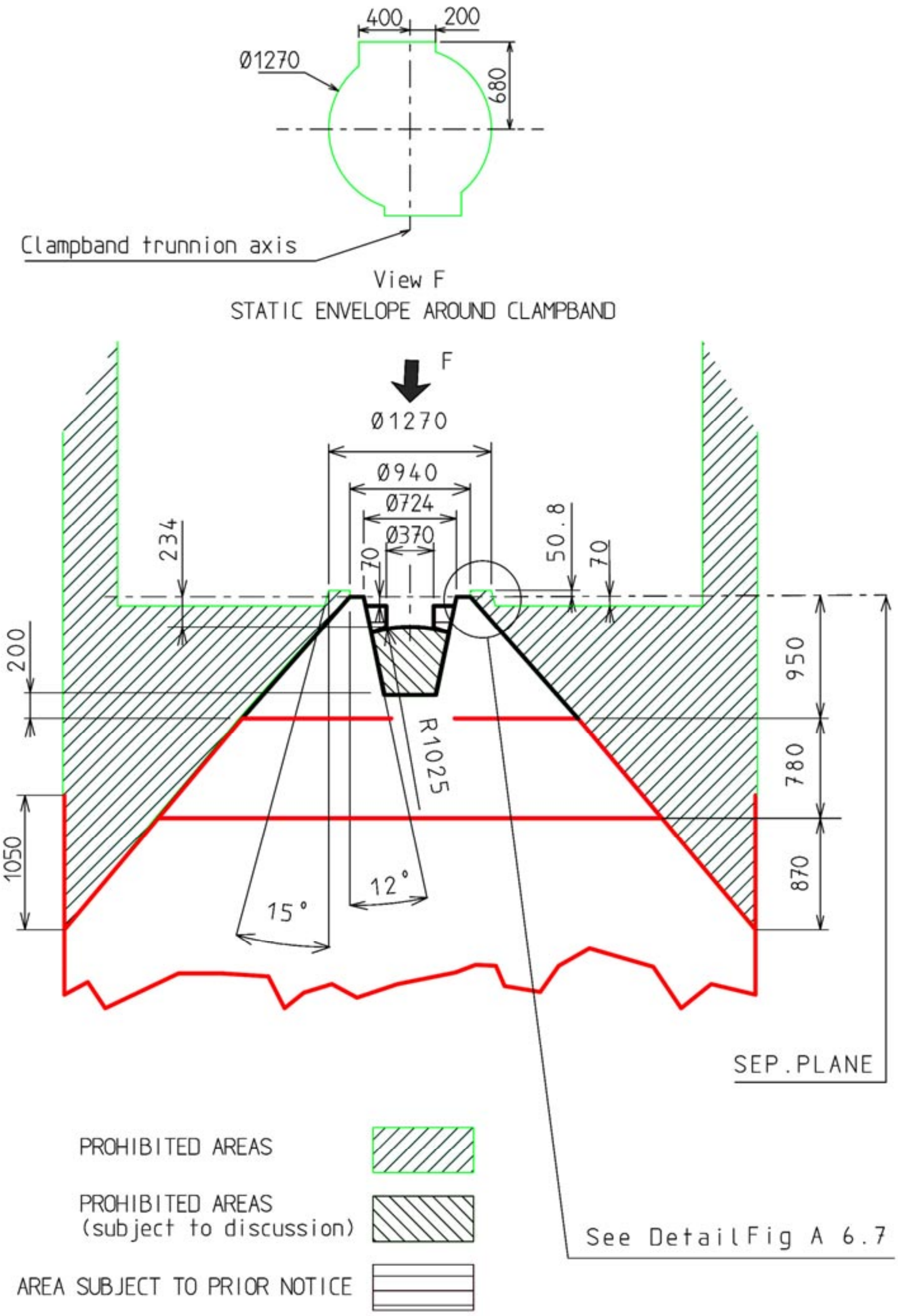


Fig. A6-8 – Adaptor 937V5
Usable volume

Adaptor 937VB5 Annex 7

This 937VB5 adaptor is a carbon fibre structure in the form of a truncated cone, with a diameter of 937 mm at the level of the spacecraft separation plane. It is attached to the reference plane (∅ 2624) by a bolted connector frame, and also provides for spacecraft separation.

The 937VB5 adaptor has a mass of 145 kg.
The actual spacecraft pair of values (Mcu, XG) must remain within admissible limits as defined in figure A7-1 using quasi-static load values as defined in paragraph 4.5.5 (chapter 4).

The spacecraft is secured to the adaptor interface frame by a clampband. This comprises a metal strip applying a series of clamps to the payload and adaptor frames. The clampband assembly comprises two half clampbands, connected by bolts which are cut pyrotechnically to release the clampband, which is then held captive by the adaptor assembly.

The clampband tension does not exceed 32 400 N at any time, it is defined to ensure no gapping between the spacecraft and adaptor interface frames in ground and flight environment.

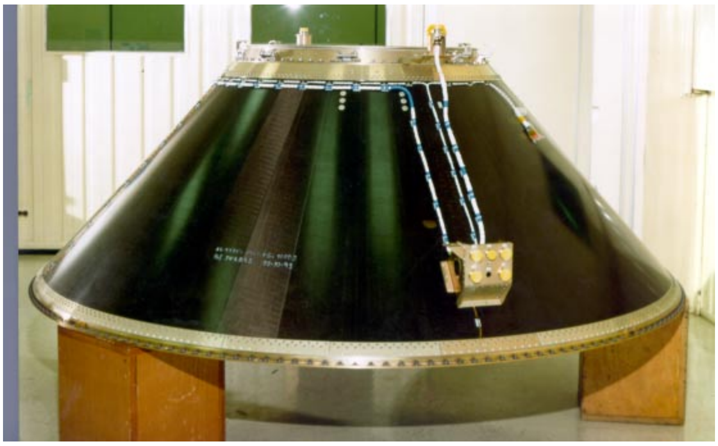
The spacecraft is forced away from the launch vehicle by 4 springs part of the adaptor and bearing on supports fixed to the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s.

The force exerted on the spacecraft by each spring does not exceed: 1 500 N.

Adaptor is equipped either with external or internal springs on user request.
The figures A7-2 and A.7-6 define the location and the design of L/V microswitches.

Umbilical connectors brackets: on the spacecraft side, the connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

Note: The adaptor cone is made of two parts: the cone itself and the upper frame. In order to ease the clampband installation, the upper frame can be dismantled from the cone. Mating of the spacecraft is, in that case, performed in two steps: clampband installation, and then bolting of the spacecraft and adaptor upper frame to the cone. To perform this operation, a stiffening tool is used which reduced the diameter of the inner usable volume to 370 mm (see figures A7-8).



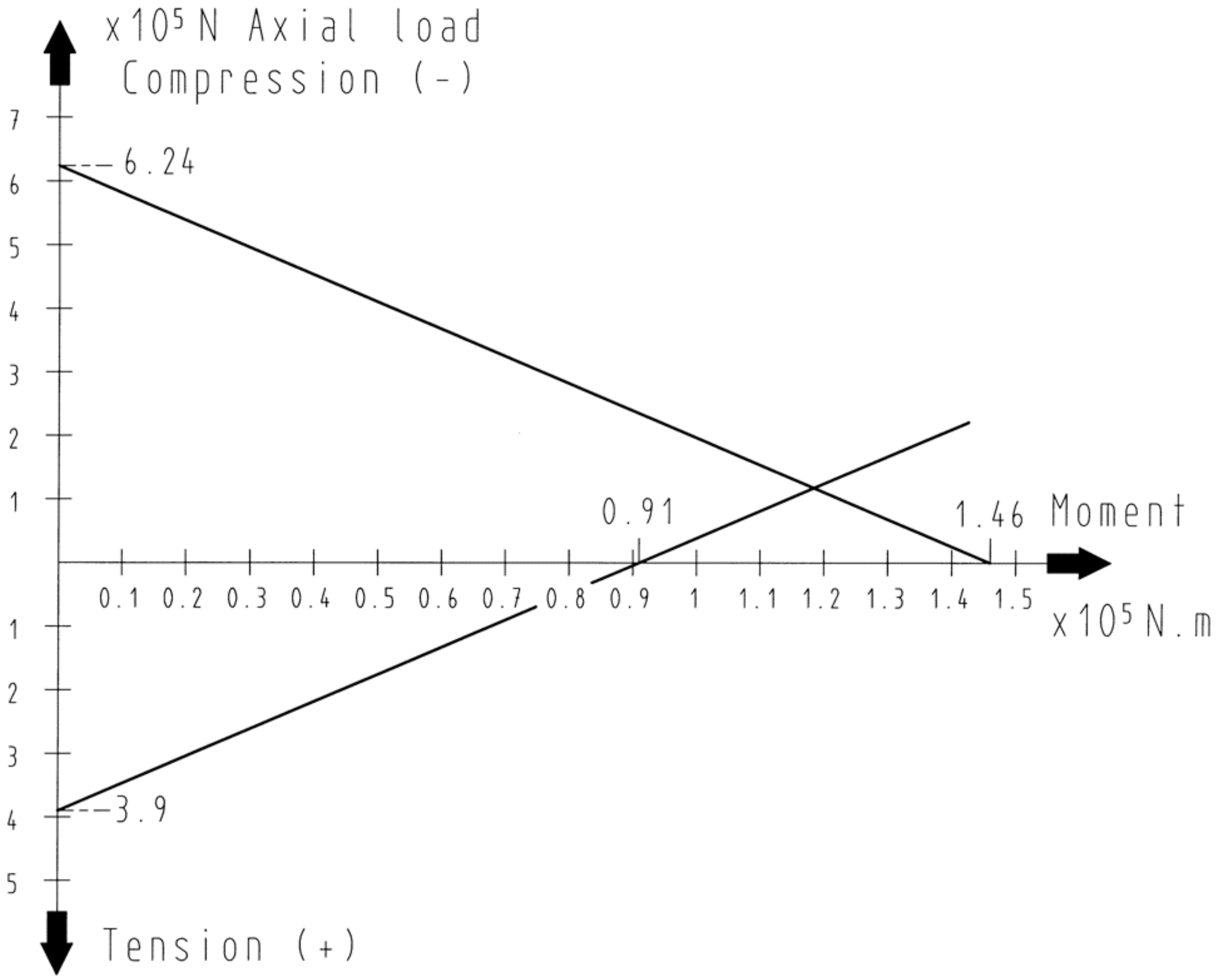


Fig. A7-1 – Limit loads of adaptor 937VB5 at separation plane

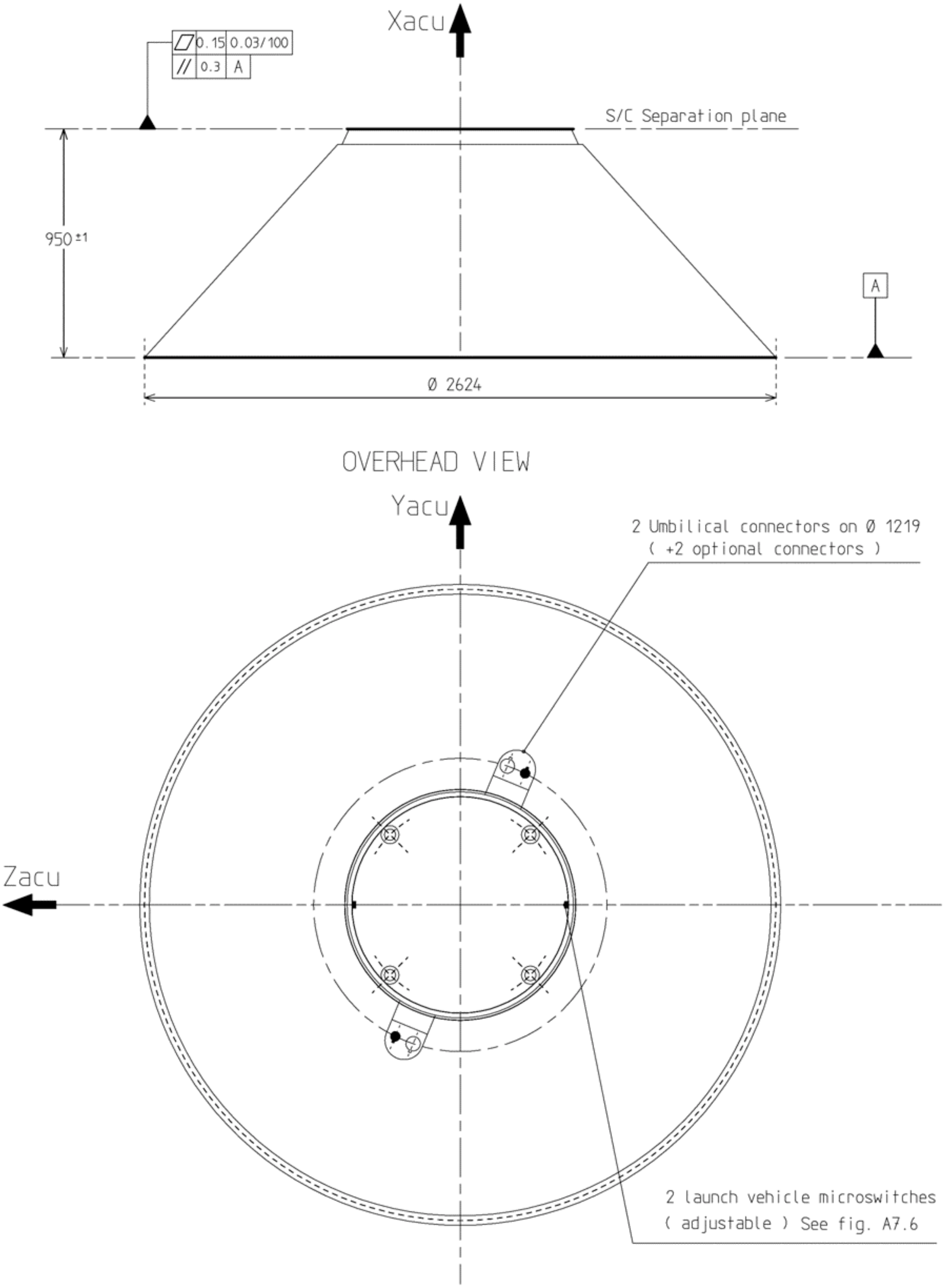


Fig. A7-2 – Adaptor 937VB5
General view and main characteristics

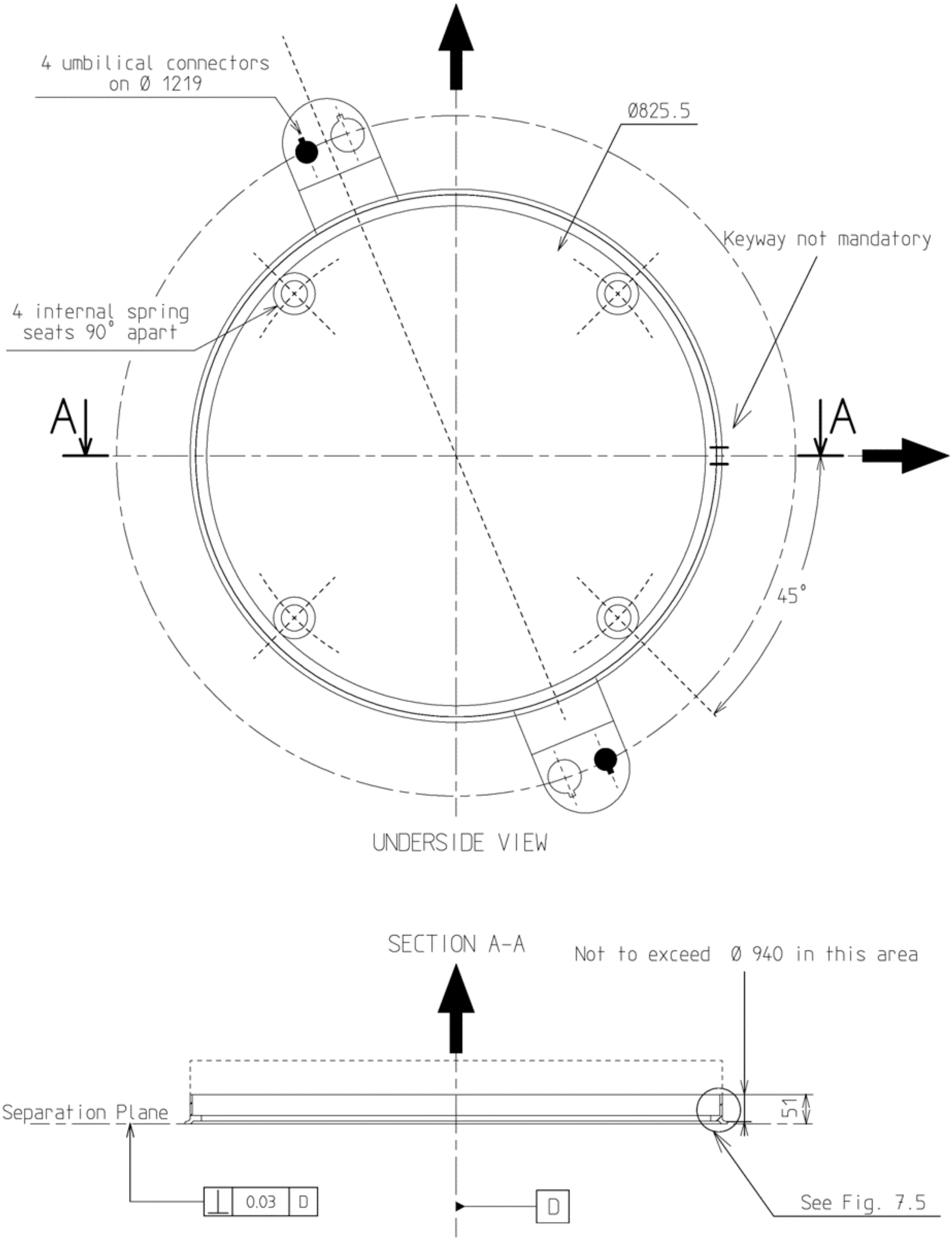


Fig. A7-3 – Adaptor 937VB5
Spacecraft configuration view and main characteristics

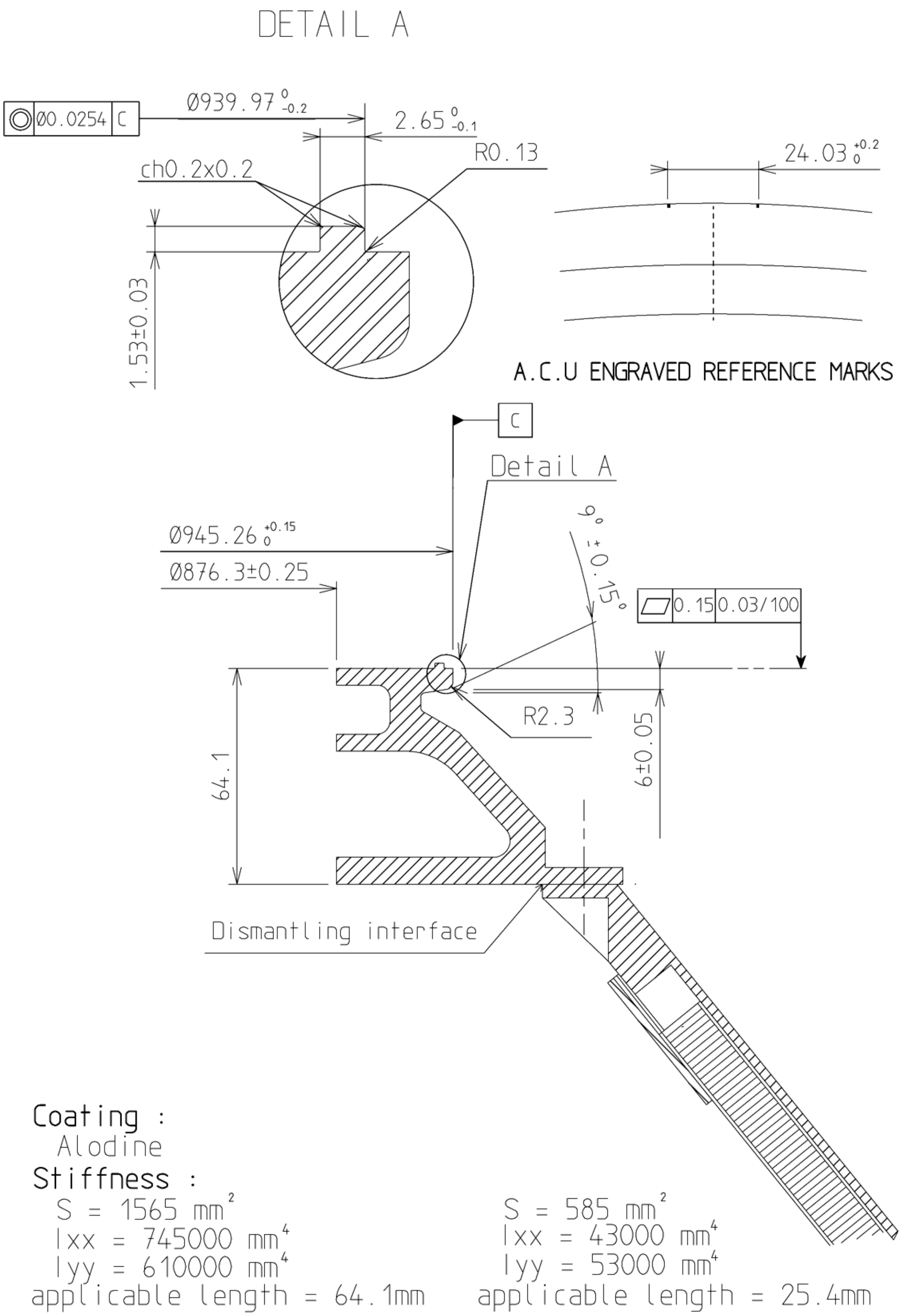


Fig. A7-4 – Adaptor 937VB5 forward frame

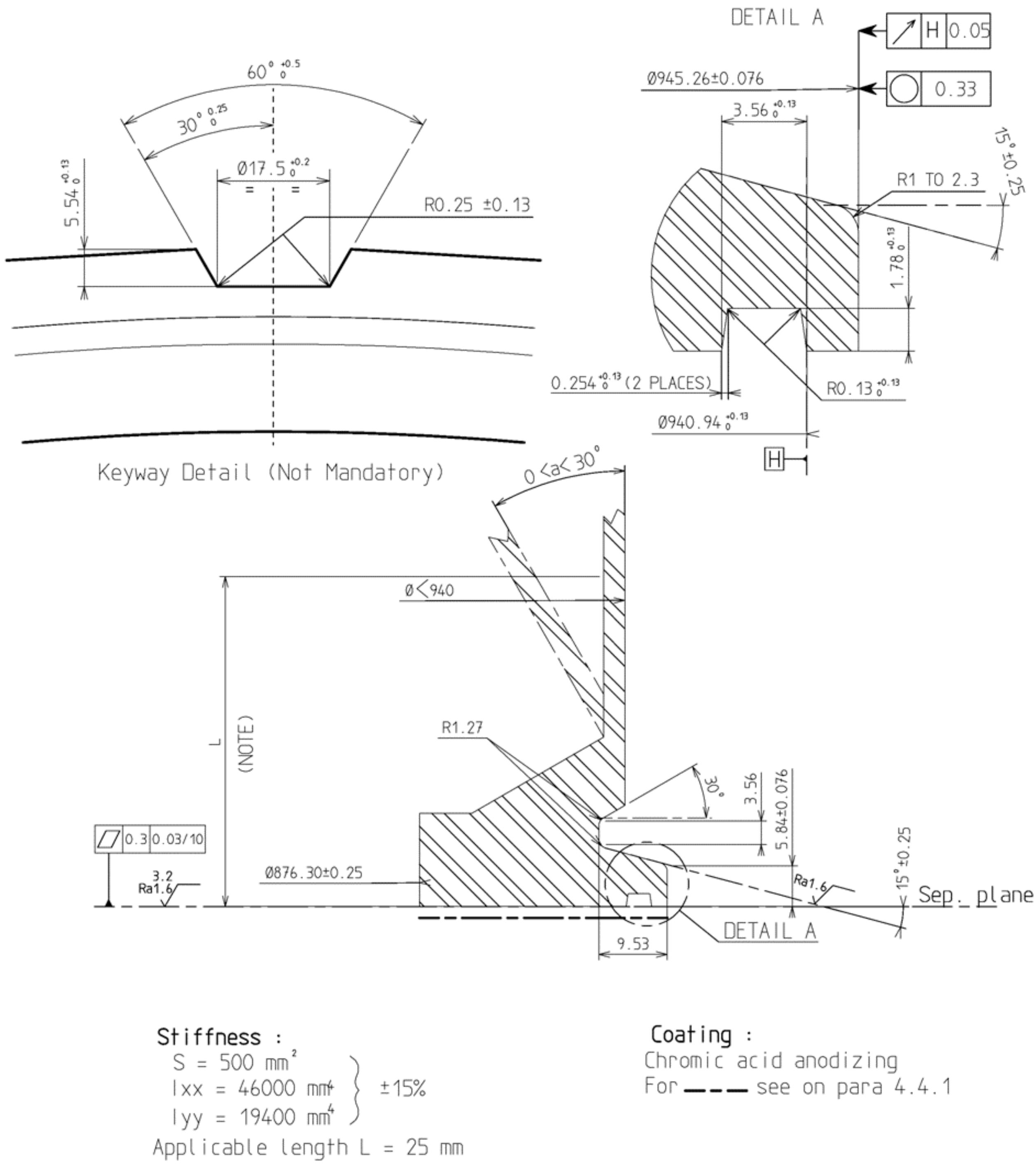


Fig. A7-5 – 937VB5 spacecraft interface frame (details)

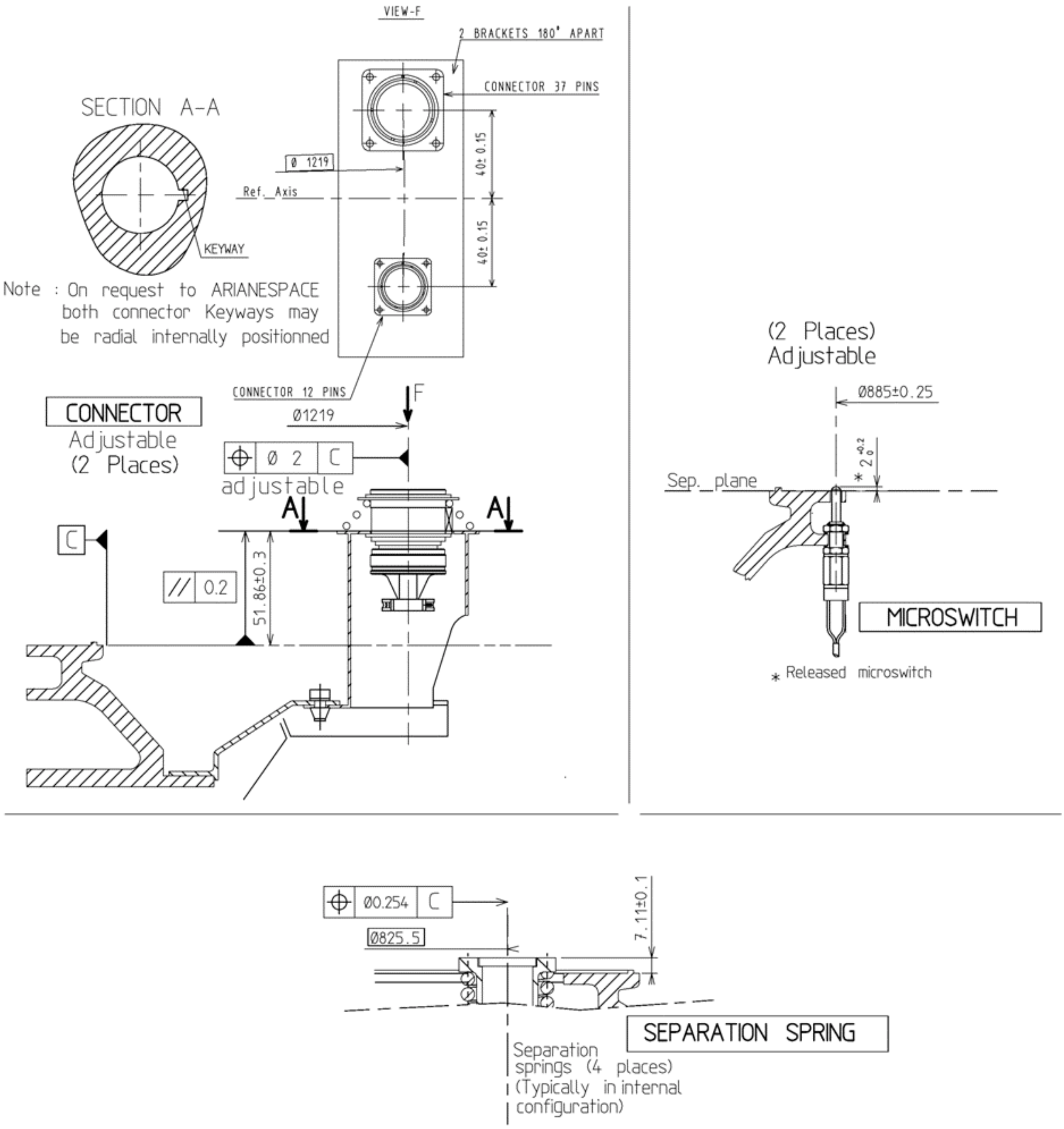


Fig. A7-6 – Adaptor 937VB5 mechanical interfaces (details)

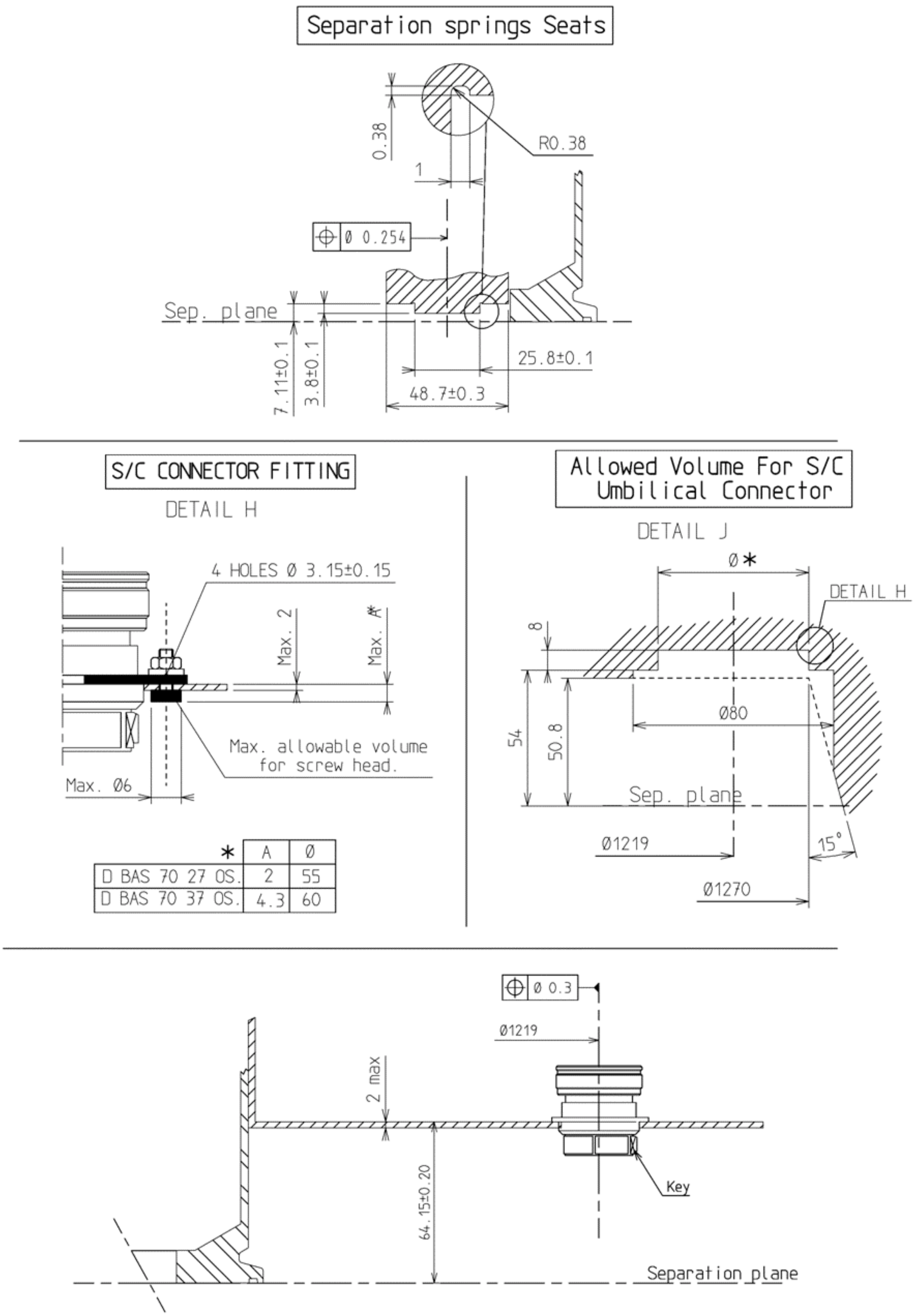


Fig. A7-7 – 937VB5 spacecraft mechanical interface (details)

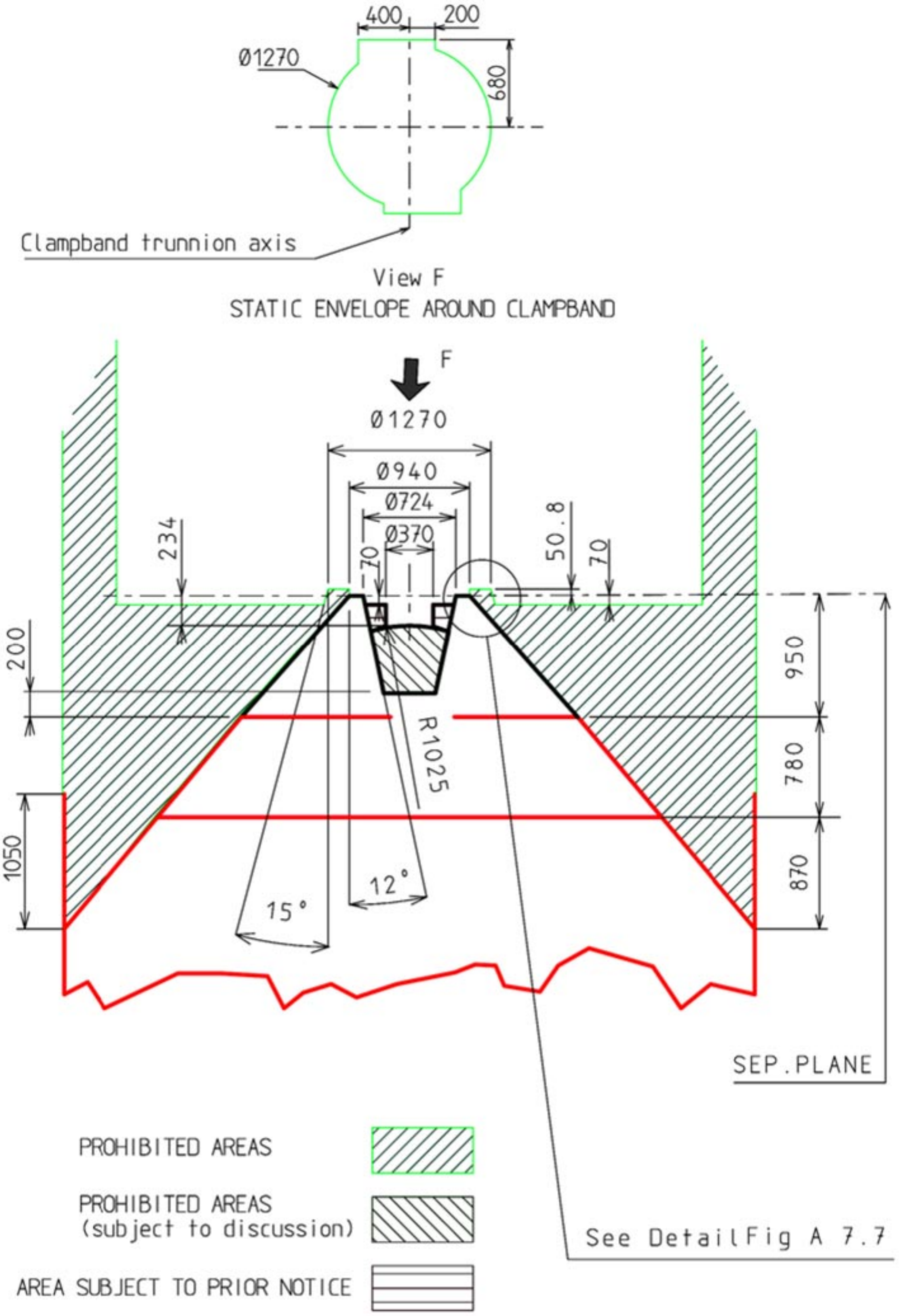


Fig. A7-8 – Adaptor 937VB5
Usable volume

Adaptor 1194V5 — Annex 8.1

This 1194V5 adaptor is a carbon fibre structure in the form of a truncated cone with a diameter of 1194 mm at the level of the spacecraft separation plane. It is attached to the ∅ 2624 reference plane by means of a bolted frame and provides for spacecraft separation.

The spacecraft rests on the forward frame of the adaptor and is secured by a clampband. The latter consists of a metal strip which holds in place a series of clamps hooked on to the spacecraft and adaptor frames. At separation, the band is severed in two places by a bolt cutter mounted on the adaptor, the pieces remaining captive to the adaptor.

The spacecraft is forced away from the launch vehicle by a series of actuators (4 to 12) forming part of the vehicle and bearing on the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s. Once the clampband is fitted, each actuator exerts a force of less than 1200 N on the rear spacecraft frame.

The actual spacecraft pair of values (Mcu, X_G) must remain within admissible limits as defined in figure A8.1-1.

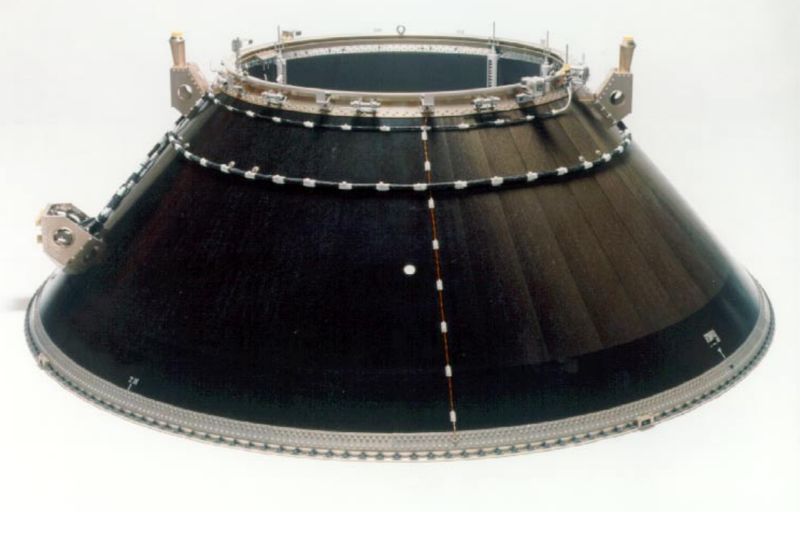
The 1194V5 adaptor has a mass of 145 kg.

Figure A8.1-4 gives the dimensions of the spacecraft-frame butt. Apart from correct observance of these dimensions, this frame must be manufactured in an aluminium alloy.

The clampband tension does not exceed 28 200 N at any time, it is defined to ensure no gapping between the spacecraft and adaptor interface frames in ground and flight environment.

The angular positionning of the spacecraft on the adaptor is ensured by alignment of engraved marks on the interfacing frames.

Umbilical connectors brackets: on the spacecraft side, the connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.



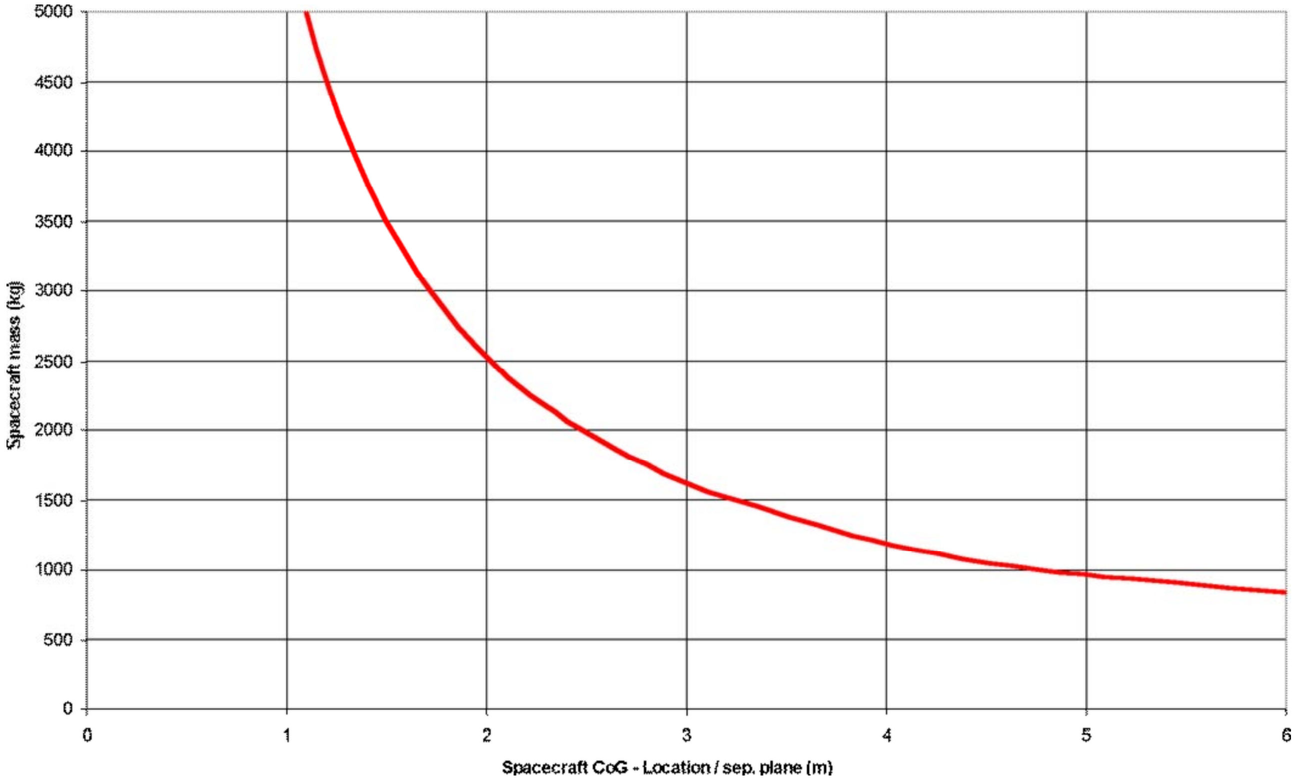


Fig. A8.1-1 – Limit loads of adaptor 1194V5 at separation plane

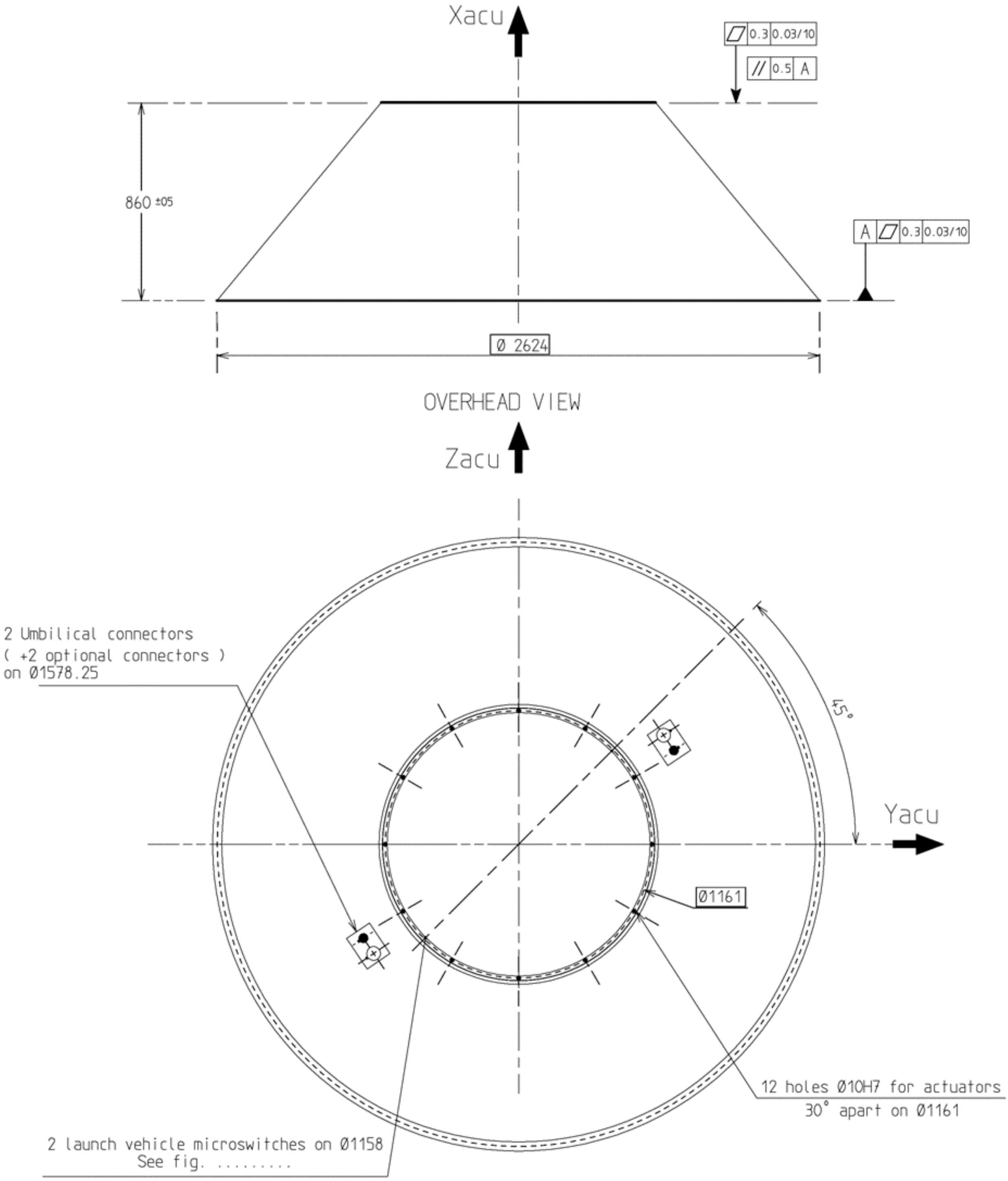


Fig. A8.1-2 – Adaptor 1194V5 - General view and main characteristics

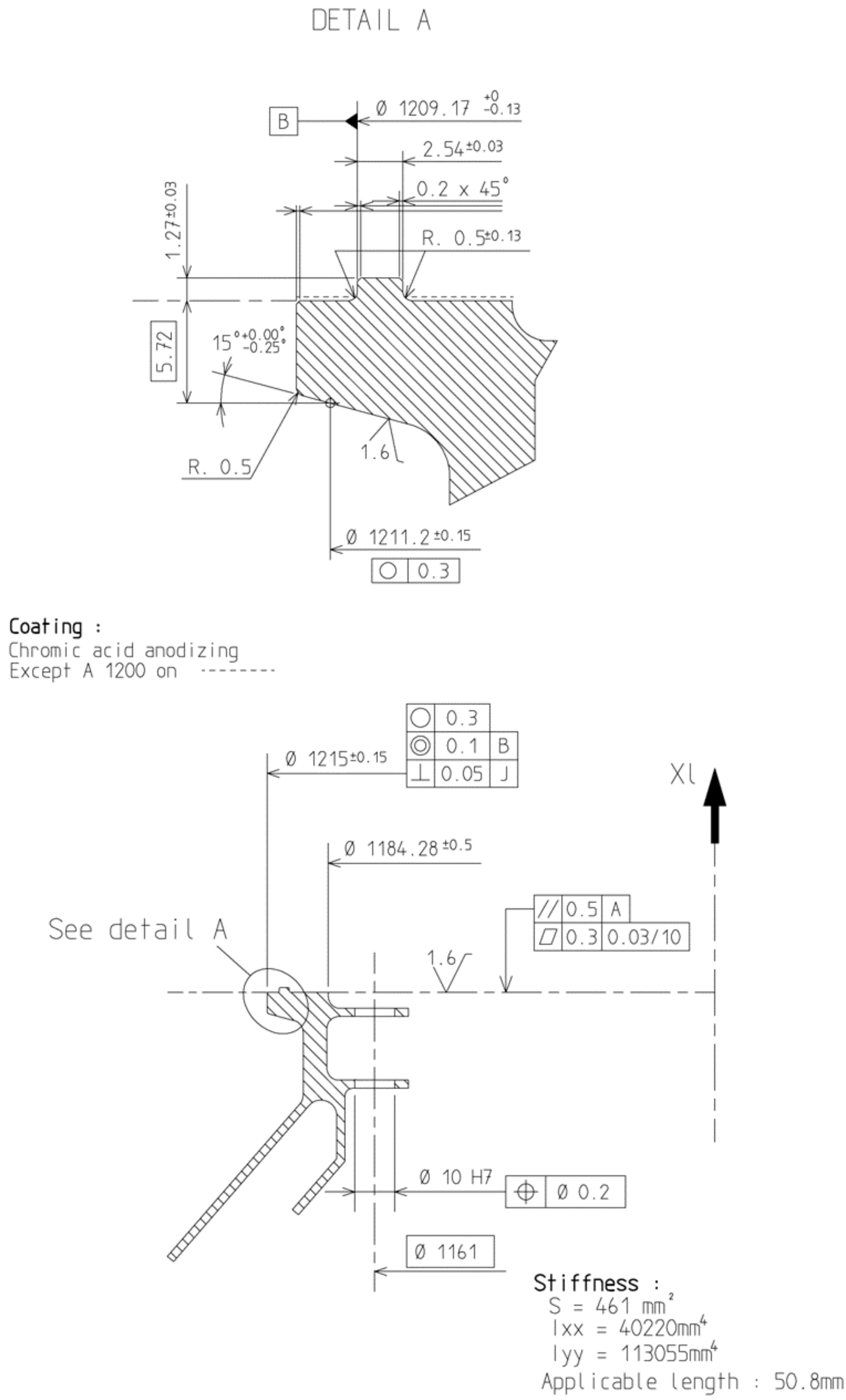


Fig. A8.1-3 – Adaptor 1194V5 – Forward frame

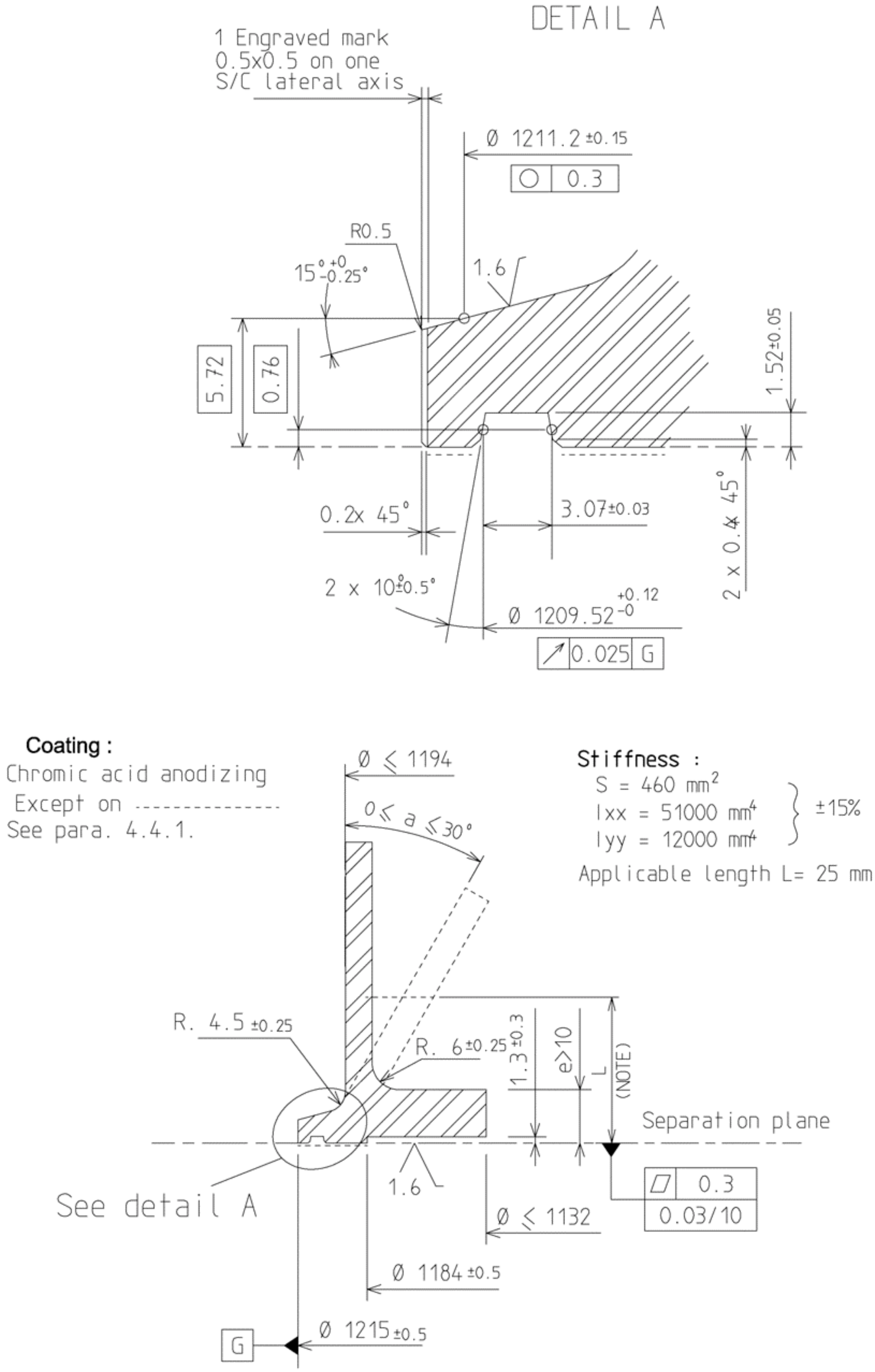


Fig. A8.1-4 – Adaptor 1194V5 – Spacecraft rear frame

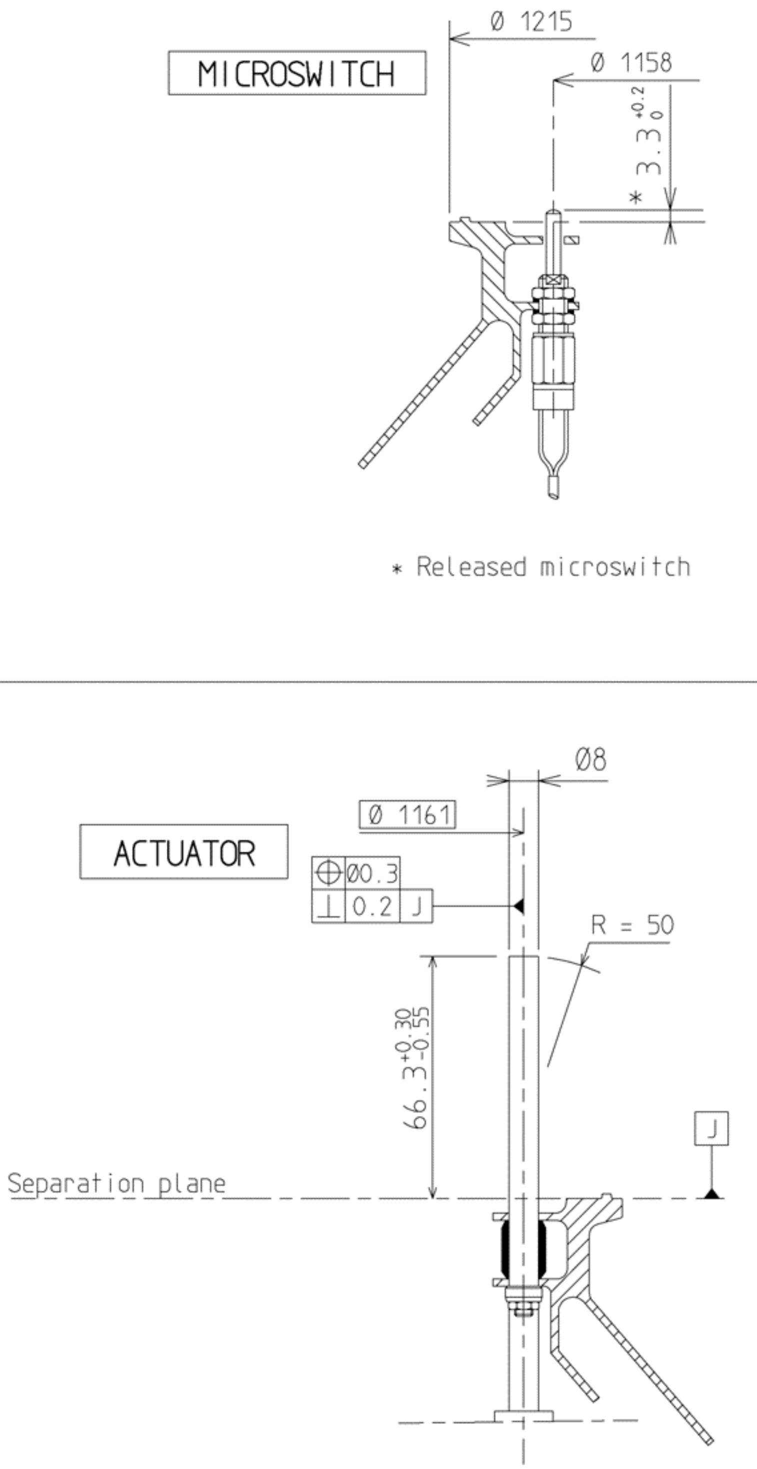


Fig. A8.1-5 – Adaptor 1194V5 - Mechanical interfaces (details)

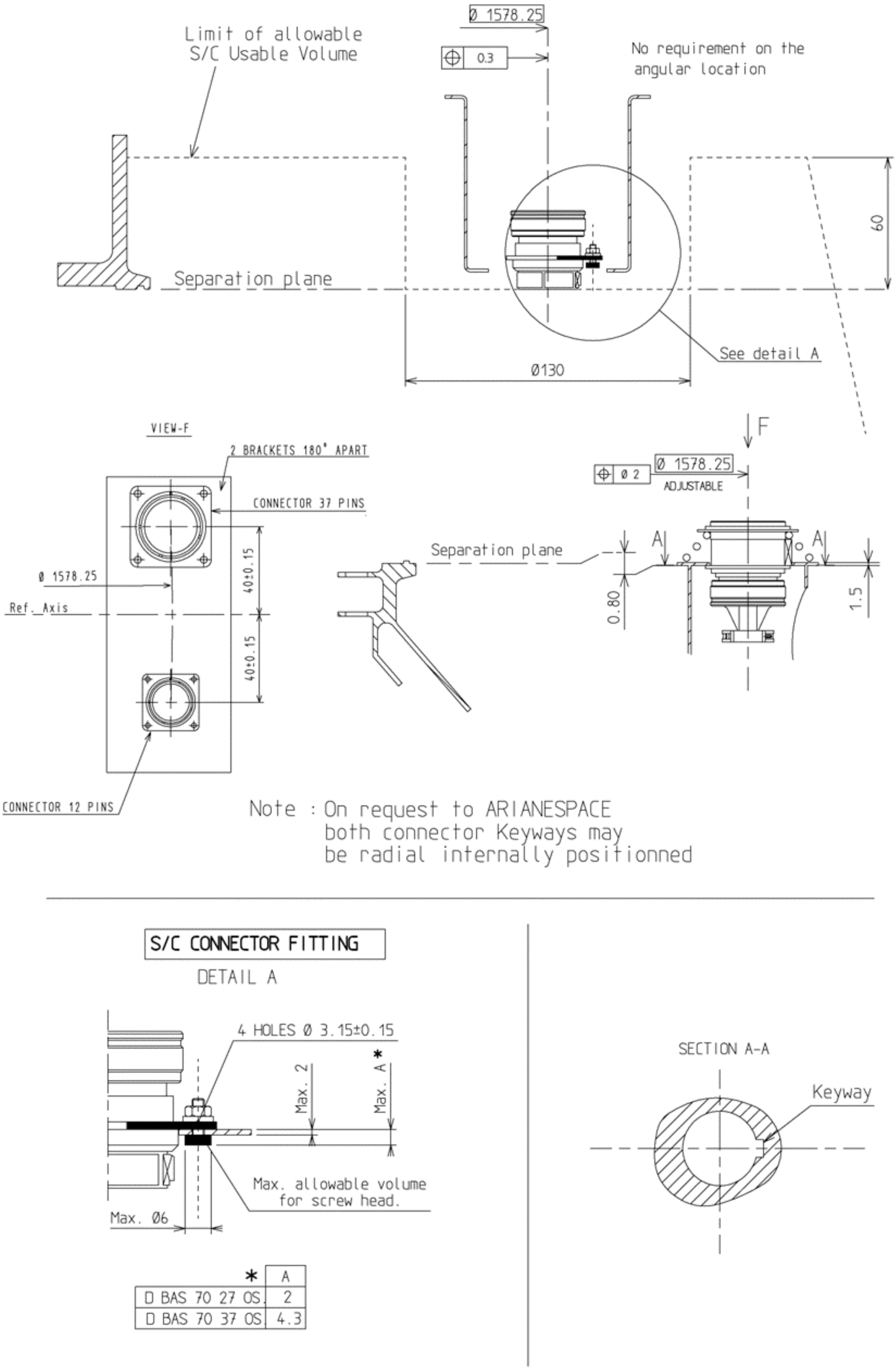


Fig. A8.1-6 – Adaptor 1194V5 - Umbilical connectors

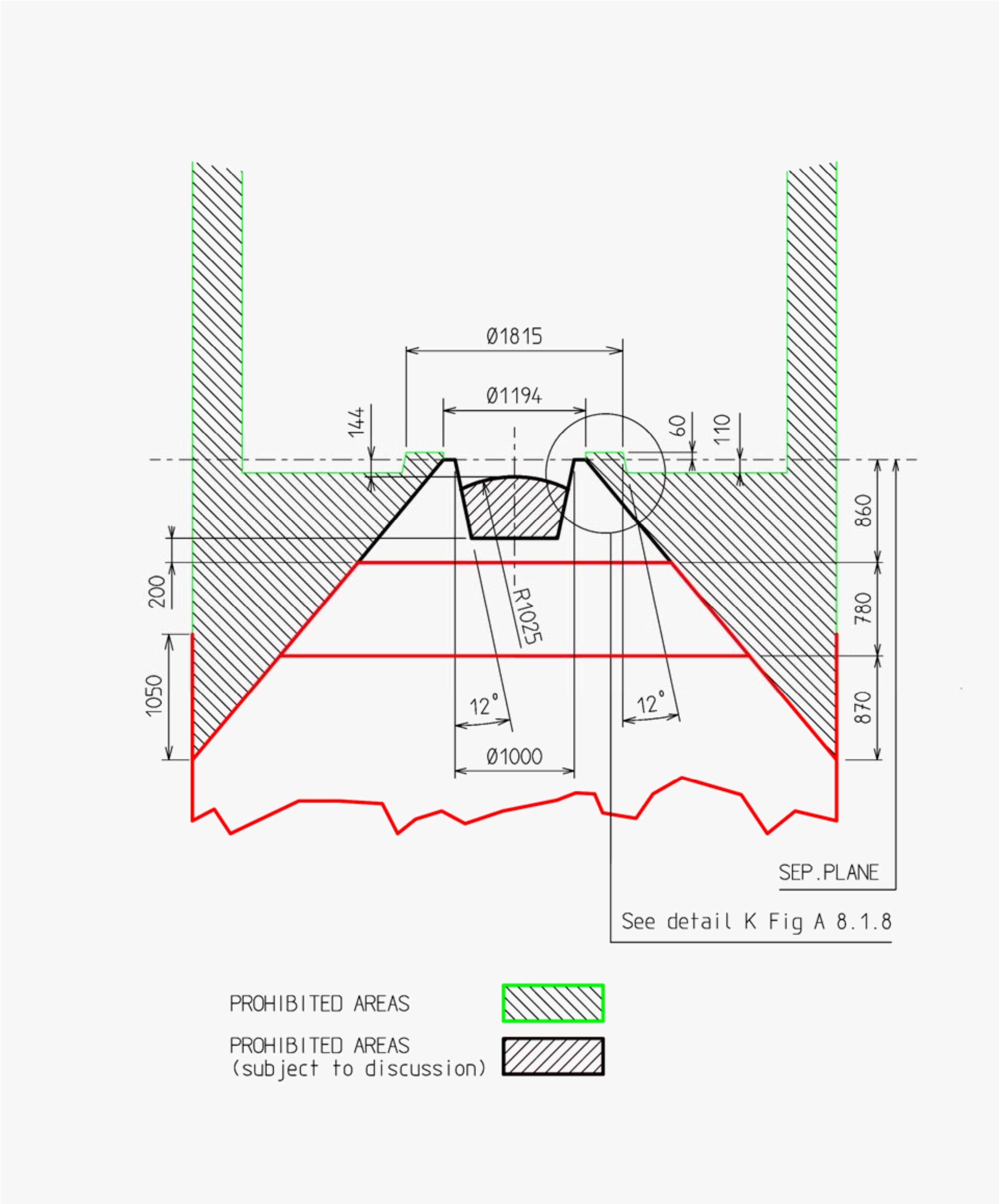


Fig. A8.1-7 – Adaptor 1194V5 - Usable volume

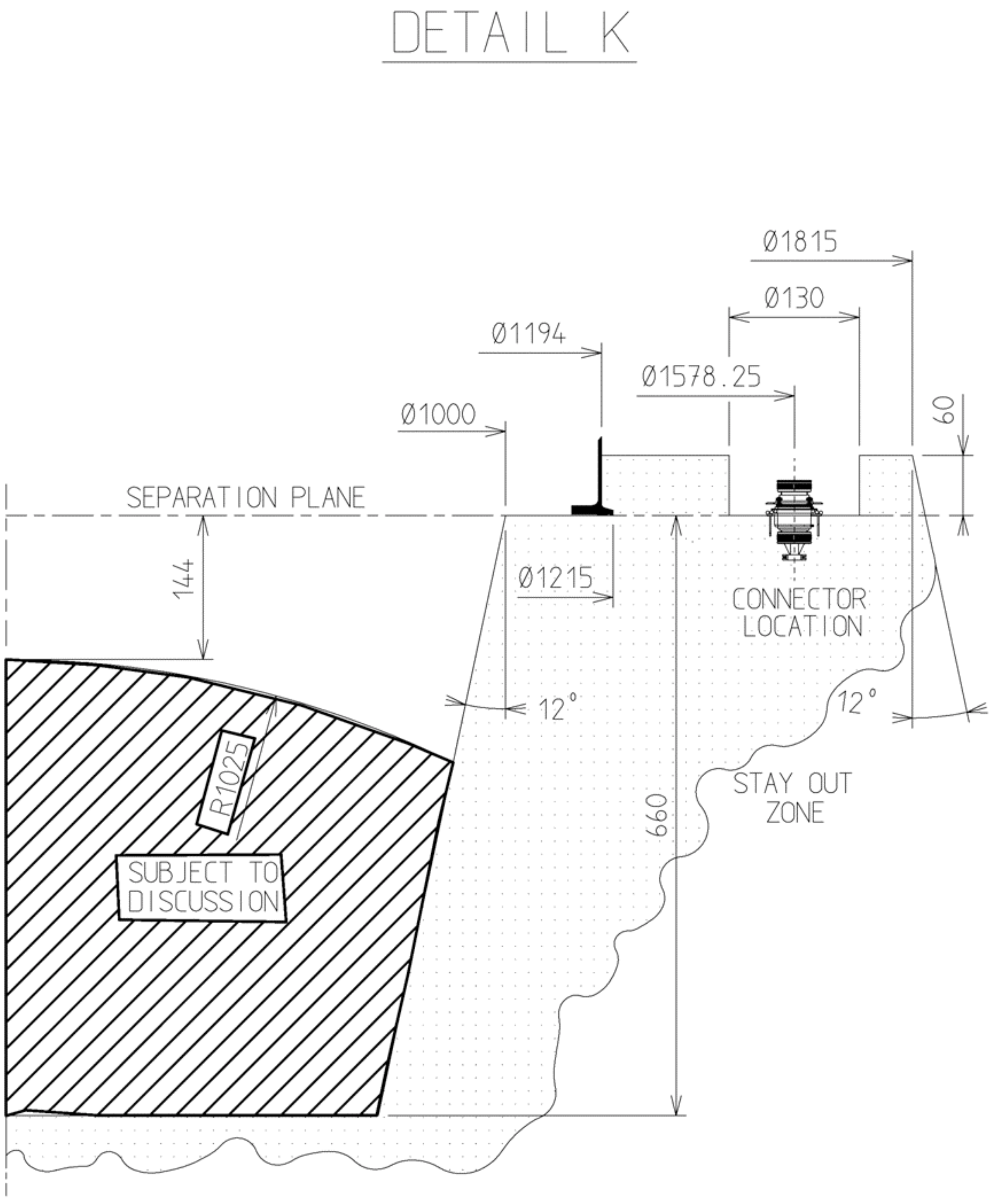


Fig. A8.1-8 – Adaptor 1194V5 - Static enveloppe around umbillcal connector

Adaptor 1194H

Annex 8.2

This 1194H adaptor is a carbon fibre structure in the form of a truncated cone with a diameter of 1194 mm at the level of the spacecraft separation plane. It is attached to the ∅ 2624 reference plane by means of a bolted frame and provides for spacecraft separation.

The spacecraft rests on the forward frame of the adaptor and is secured by a clampband. The latter consists of a metal strip which holds in place a series of clamps hooked on to the spacecraft and adaptor frames. At separation, the band is severed in one place by two bolt cutters mounted on the adaptor, the pieces remaining captive to the adaptor.

In free conditions the clampband diameter is 80 mm greater than the interface rings diameter which ensure an auto extraction. When closed, the band perimeter is smaller than the interface rings. In order to install and tension the band, the later is heated up to 100 °C with a belt heater. The band is then closed and the bolts torqued. Cooling down of the band at ambient temperature results in the tensioning of the band. It should be noted that during the all process the maximum temperature reached on the spacecraft ring is 40°C.

The spacecraft is forced away from the launch vehicle by a series of actuators (4 to 12) forming part of the vehicle and bearing on the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s. Once the clampband is fitted, each actuator exerts a force of less than 1200 N on the rear spacecraft frame.

The adaptor is designed to carry a mass of 6400 kg with a Center of Gravity at 2 m above the separation plane.

The 1194H adaptor has a mass of 160 kg.

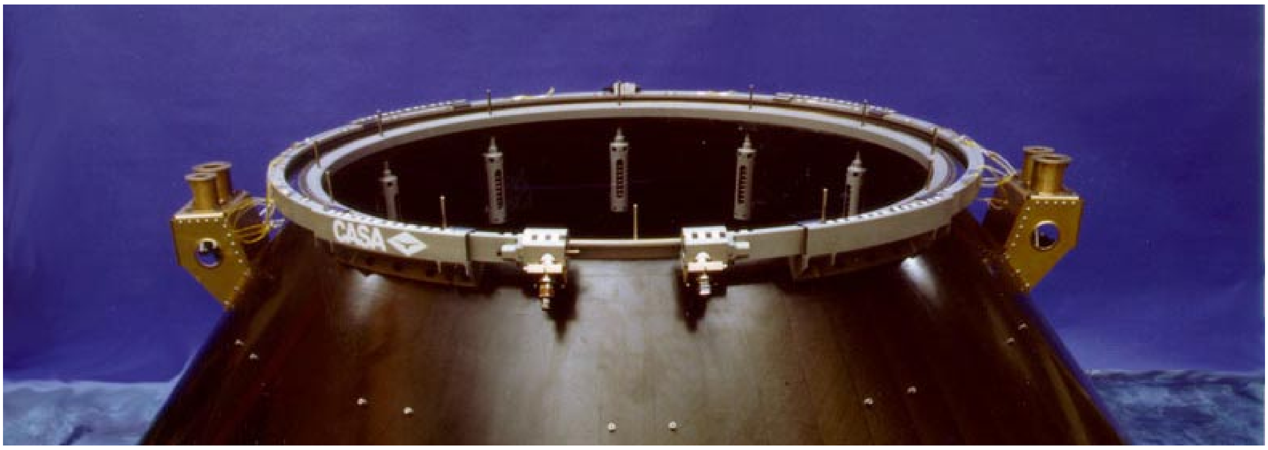
Figure A8.2-4 gives the dimensions of the spacecraft-frame butt. Apart from correct observance of these dimensions, this frame must be manufactured in an aluminium alloy.

The clampband tension does not exceed 35 000 N at any time, it is defined to ensure no gapping between the spacecraft and adaptor interface frames in ground and flight environment.

The angular positionning of the spacecraft on the adaptor is ensured by alignment of engraved marks on the interfacing frames.

The angular positionning of the spacecraft on the adaptor is ensured by alignment of engraved marks on the interfacing frames.

Umbilical connectors brackets: on the spacecraft side, the connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.



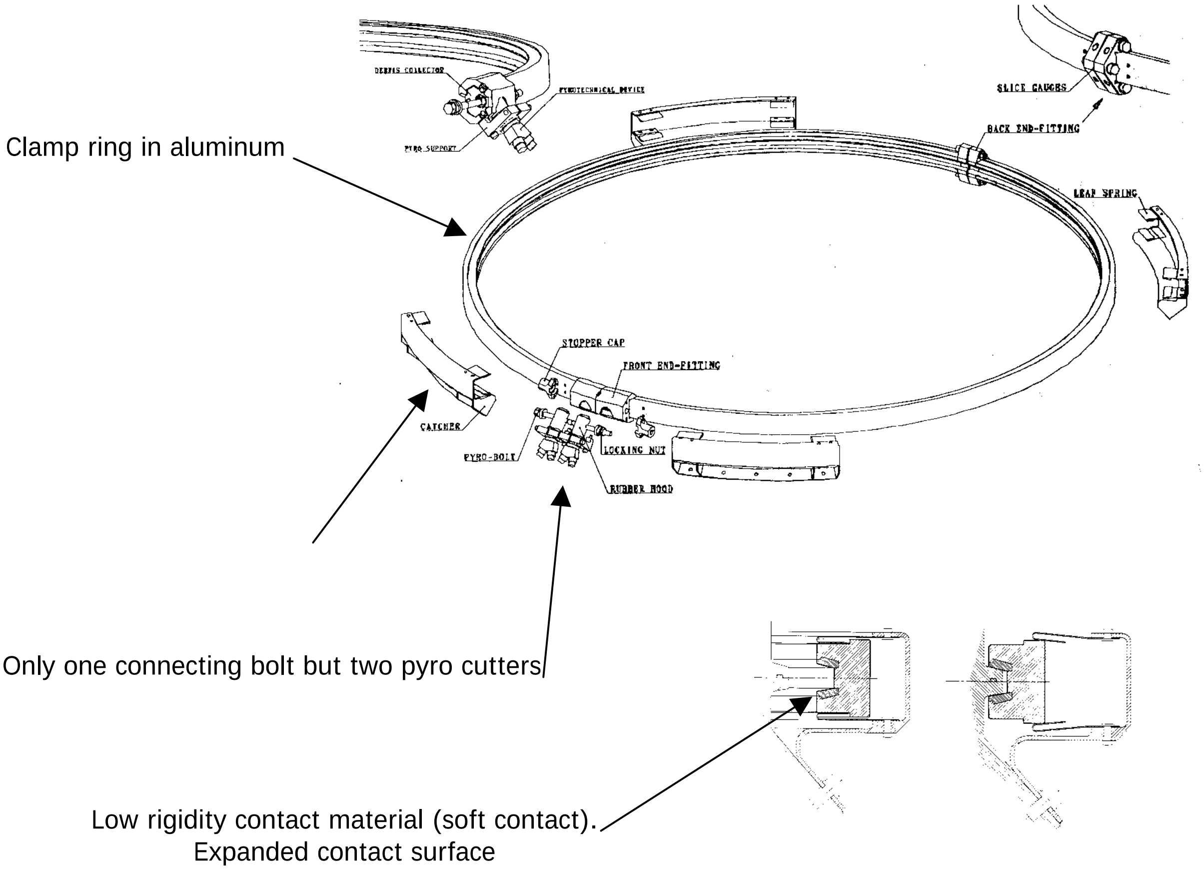


Fig. A8.2-1 – 1194H Clampband

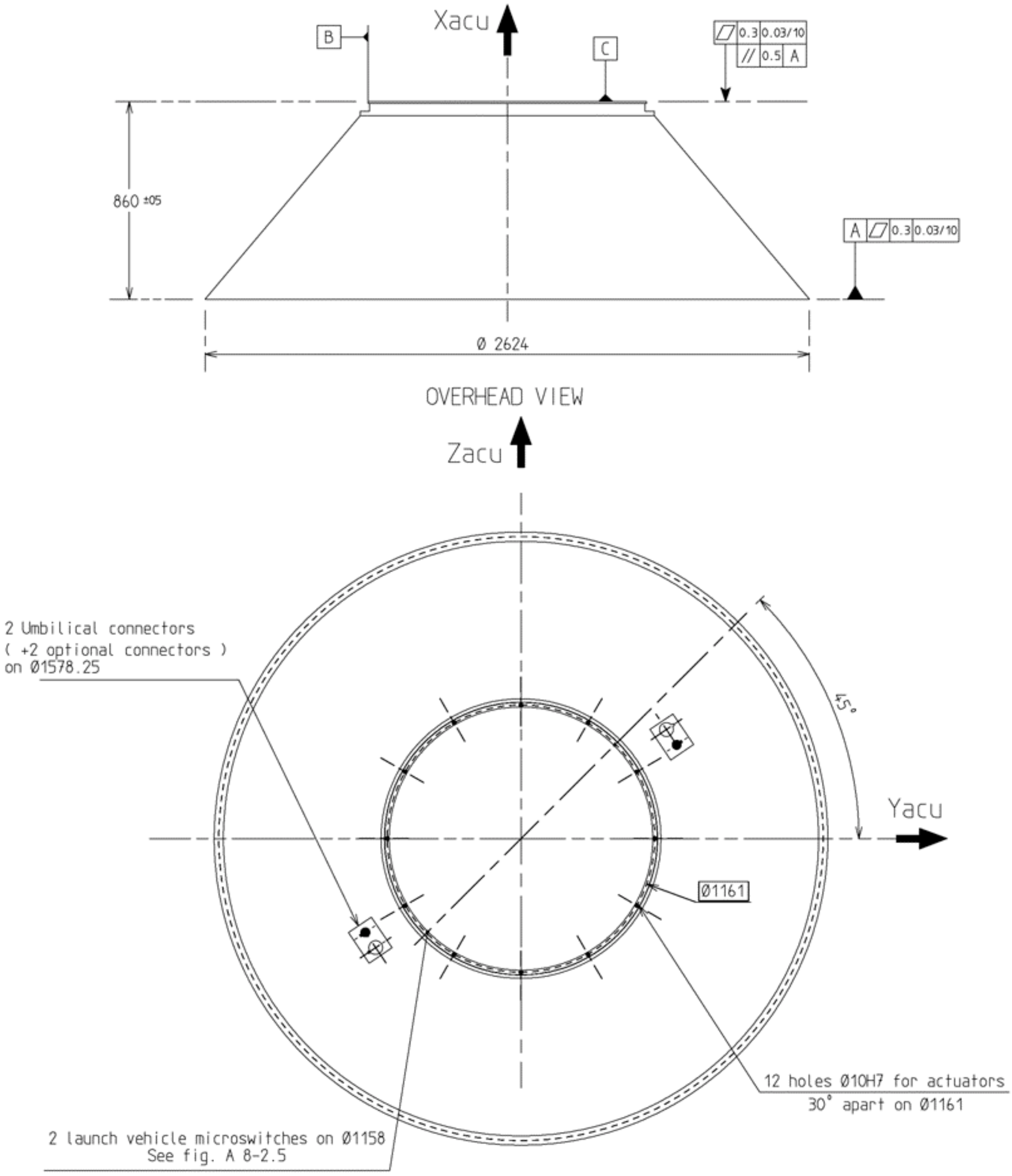


Fig. A8.2-2 – Adaptor 1194H - General view and main characteristics

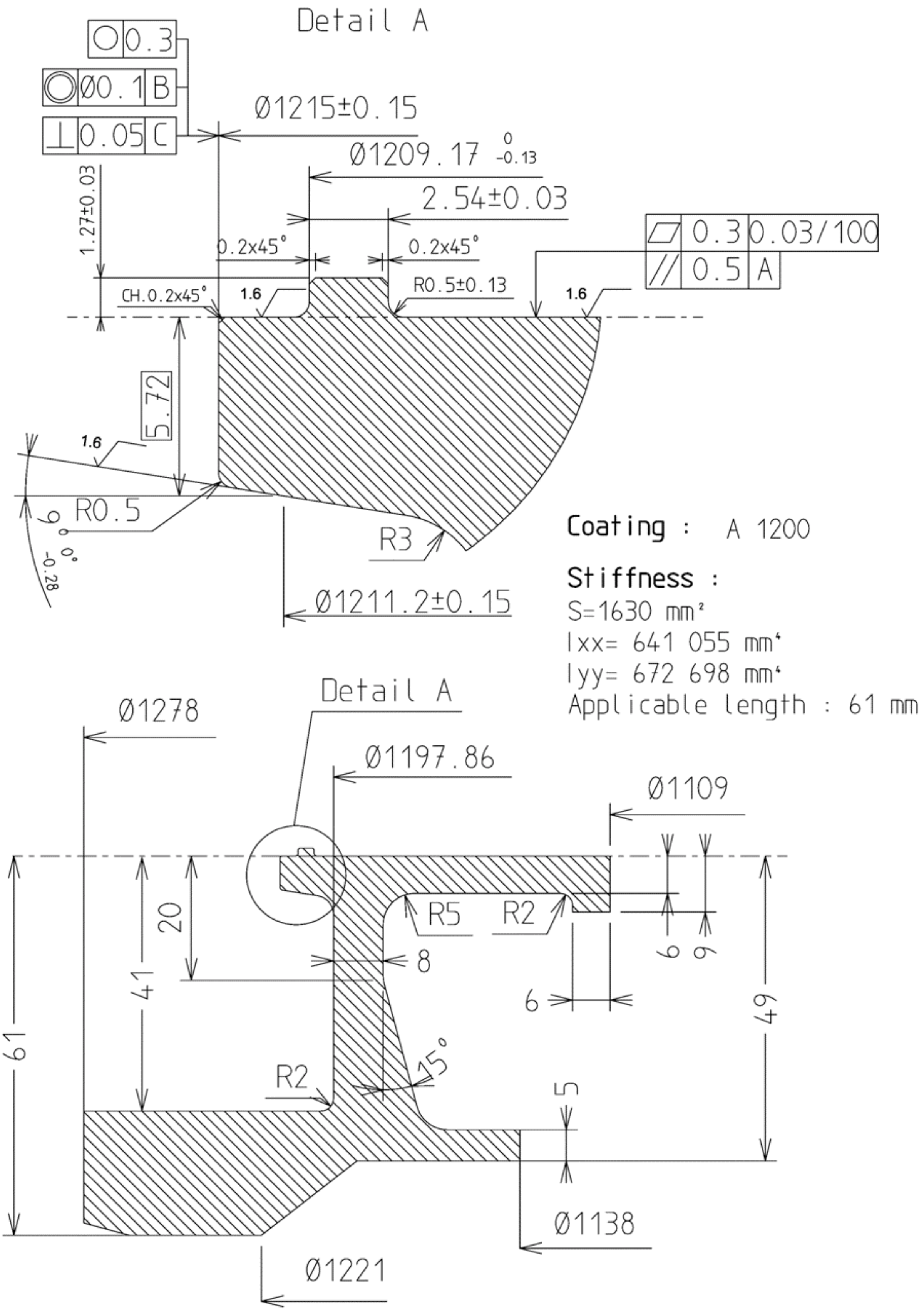


Fig. A8.2-3 – Adaptor 1194H – Forward frame

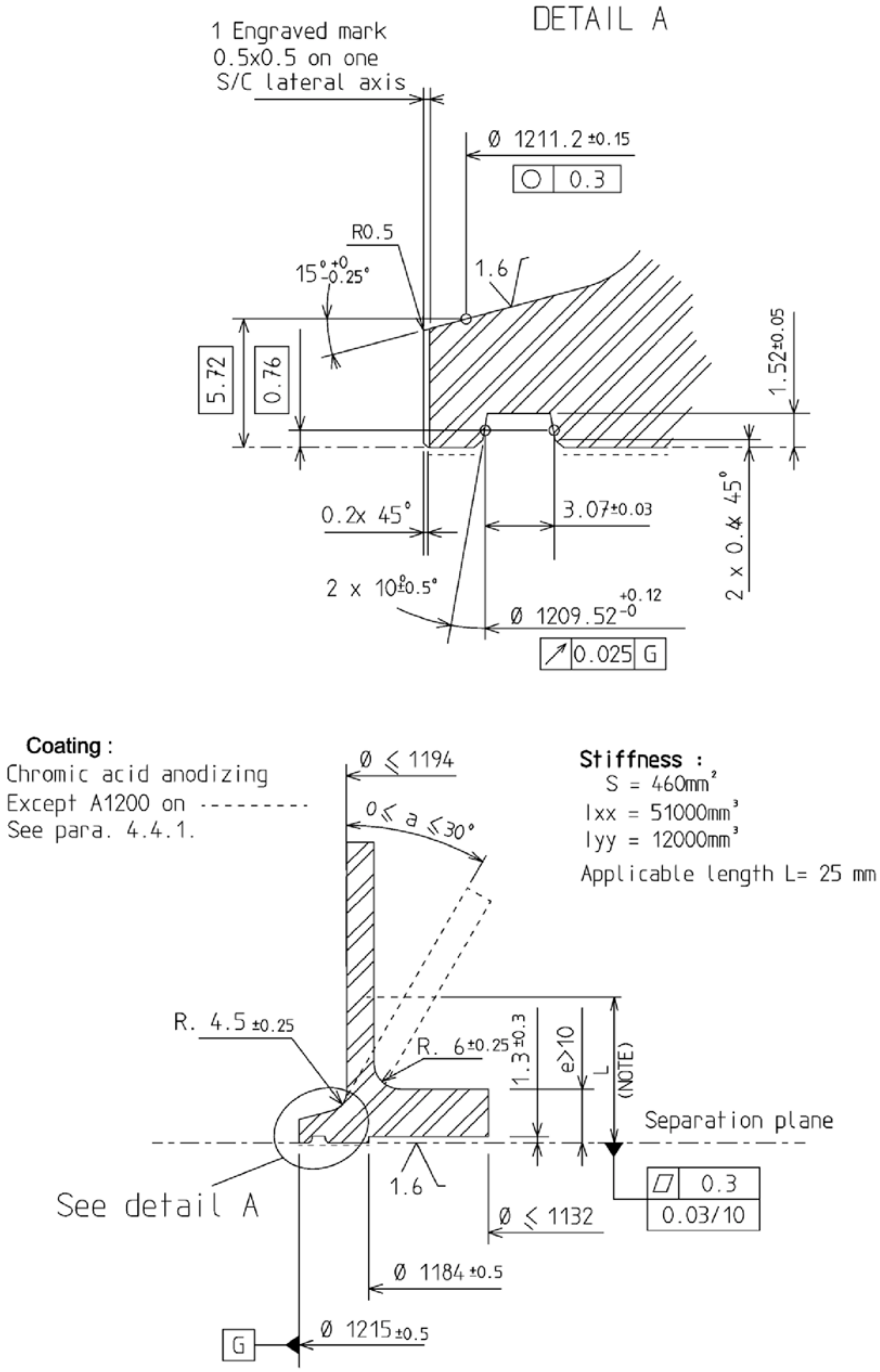


Fig. A8.2-4 – Adaptor 1194H – Spacecraft rear frame

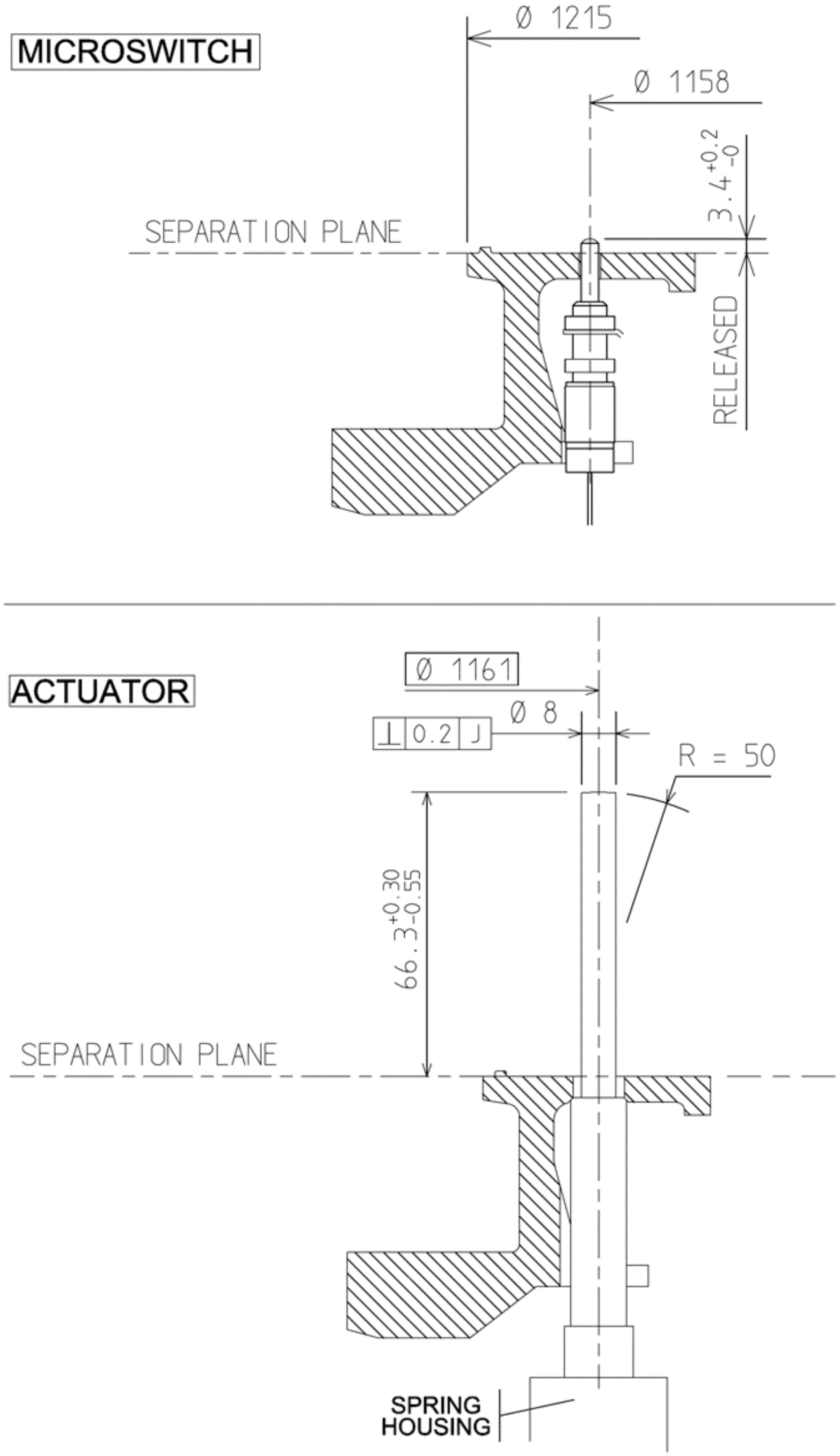
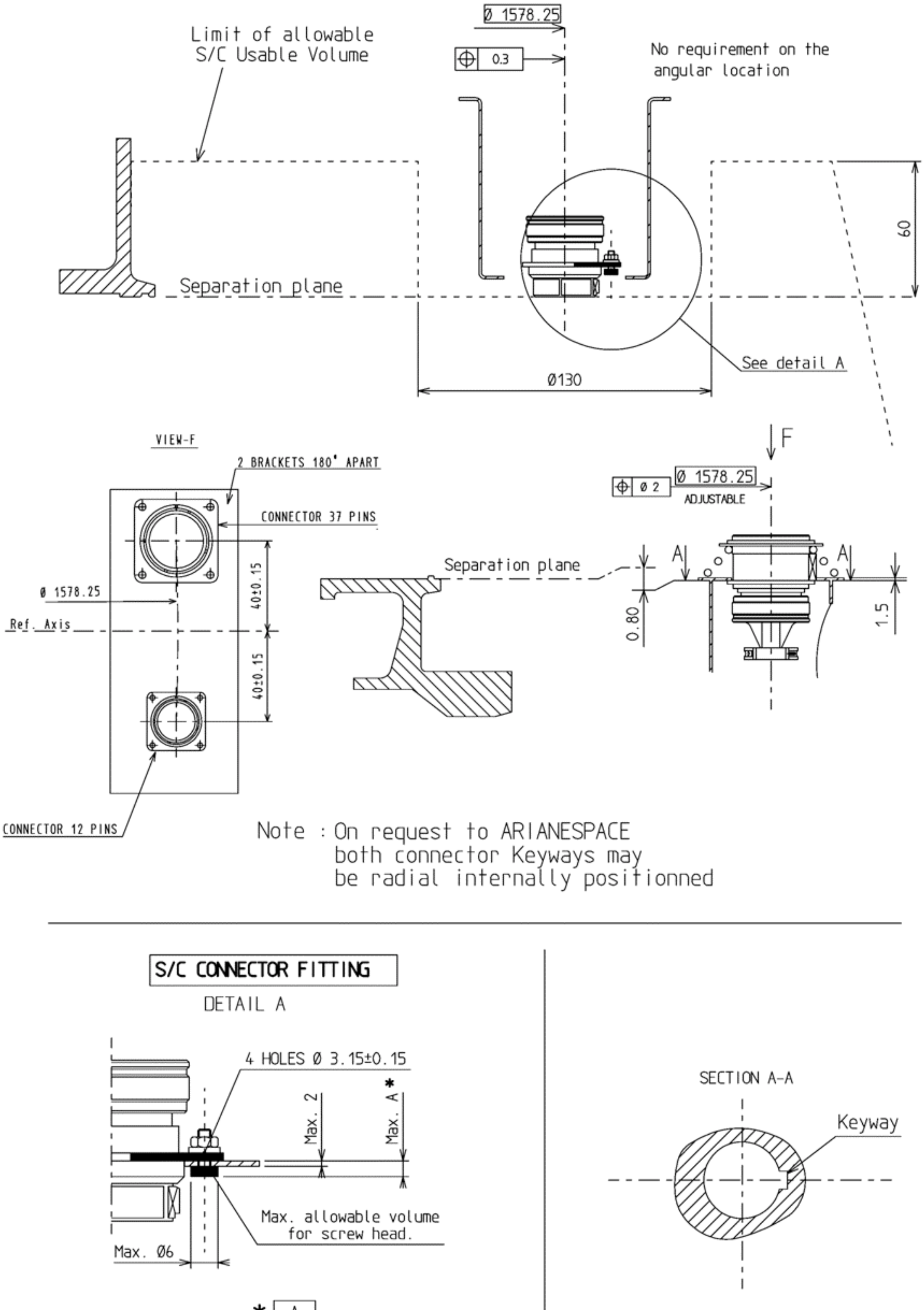


Fig. A8.2-5 – Adaptor 1194H - Mechanical interfaces (details)



*	A
D BAS 70 27 OS	2
D BAS 70 37 OS	4.3

Fig. A8.2-6 – Adaptor 1194H - Umbilical connectors

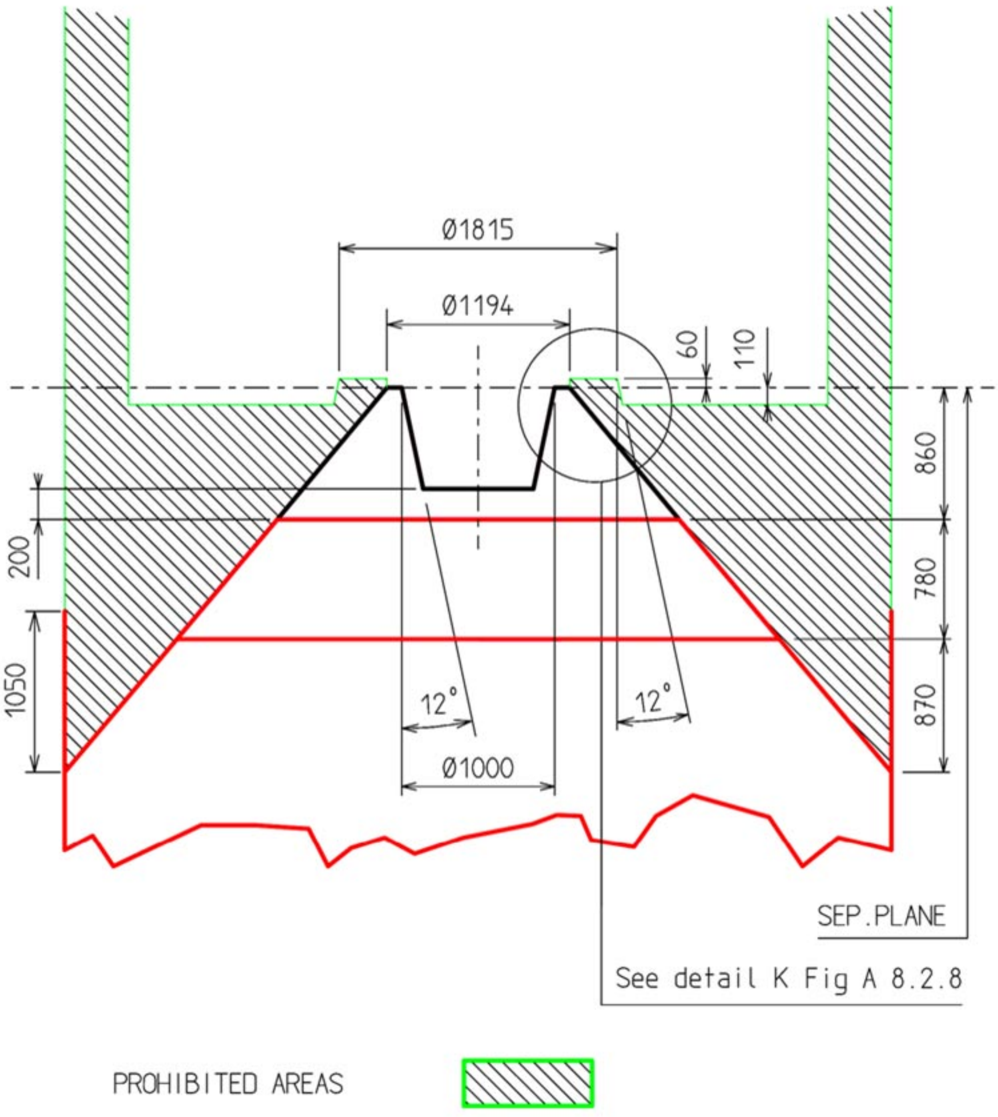


Fig. A8.2-7 – Adaptor 1194H - Usable volume

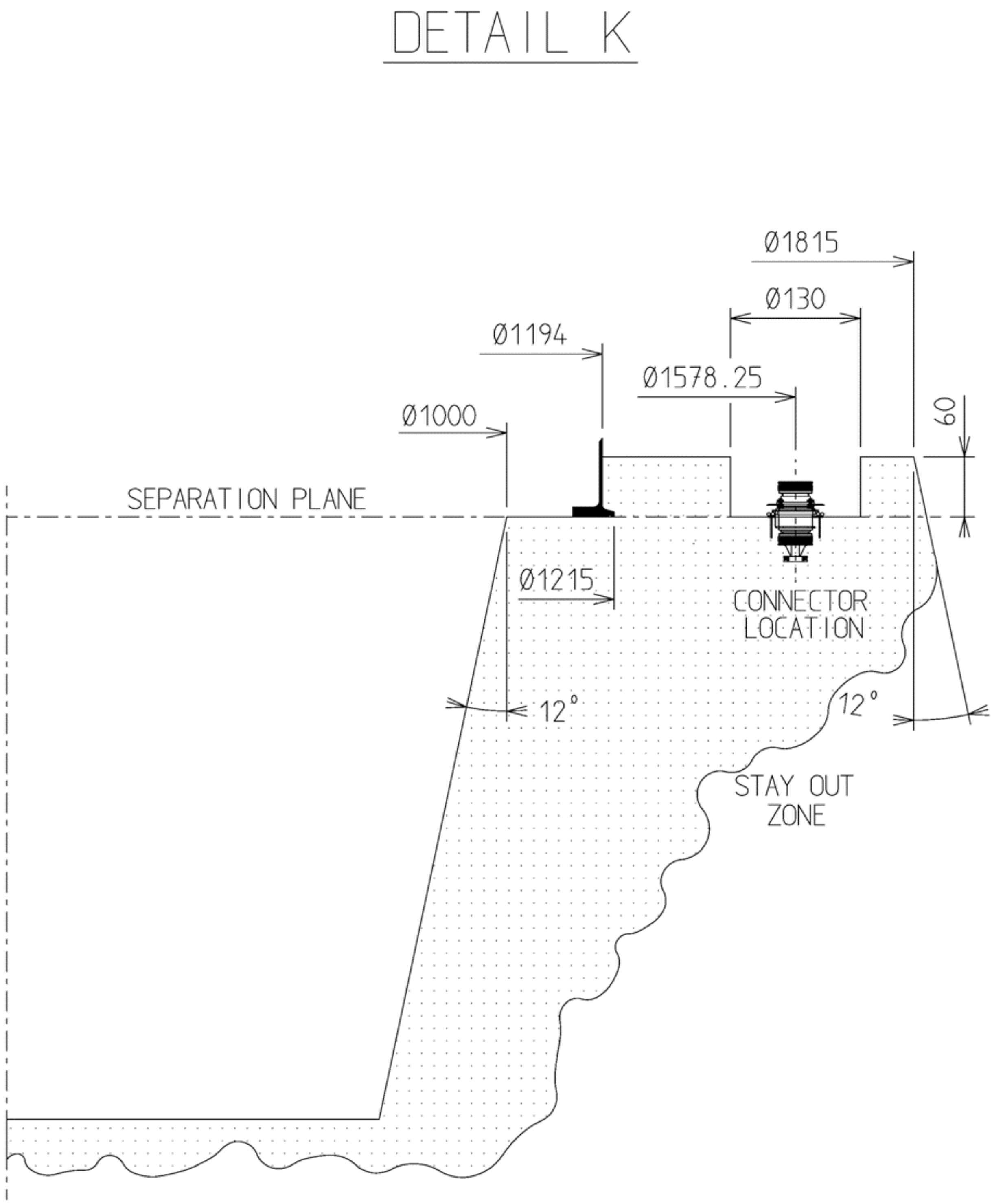


Fig. A8.2-8 – Adaptor 1194H - Static enveloppe around umbilical connector

Adaptor 1663SP5 — Annex 9

This adaptor is a carbon fibre truncated cone structure connected to the spacecraft with 4 bolts, arranged on a 1633.7 mm circle. It's rear frame is bolted to the ∅ 2624 reference plane. The adaptor provides for spacecraft separation.

At separation, the separation nuts are operated by gas pressure generated by booster cartridges. The threaded segments displace away from the bolts whose stored energy causes them to eject from the nuts.

The spacecraft is pushed away from the launch vehicle by 4 springs sets fixed on the adaptor which bear the spacecraft rear frame.

The springs are designed to release energy in the range of 50 to 150 J. The maximum spring force for each springs is 1752N.

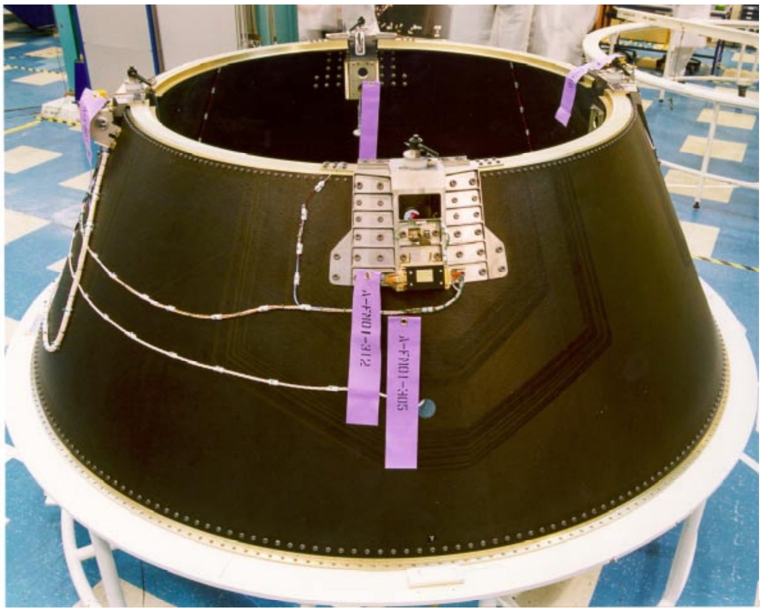
The 1663SP55 adaptor has a mass of 160 kg.

The actual pair of values (M_{cu}, X_G) must remain admissible limits as defined in Fig. 9-1.

The spacecraft rear parts in contact with the adaptator must be manufactured from Aluminium alloy.

The correct positioning of the spacecraft on the adaptor is ensured by 4 titanium shears cones.

For the definition of the loads introduction please contact ARIANESPACE.



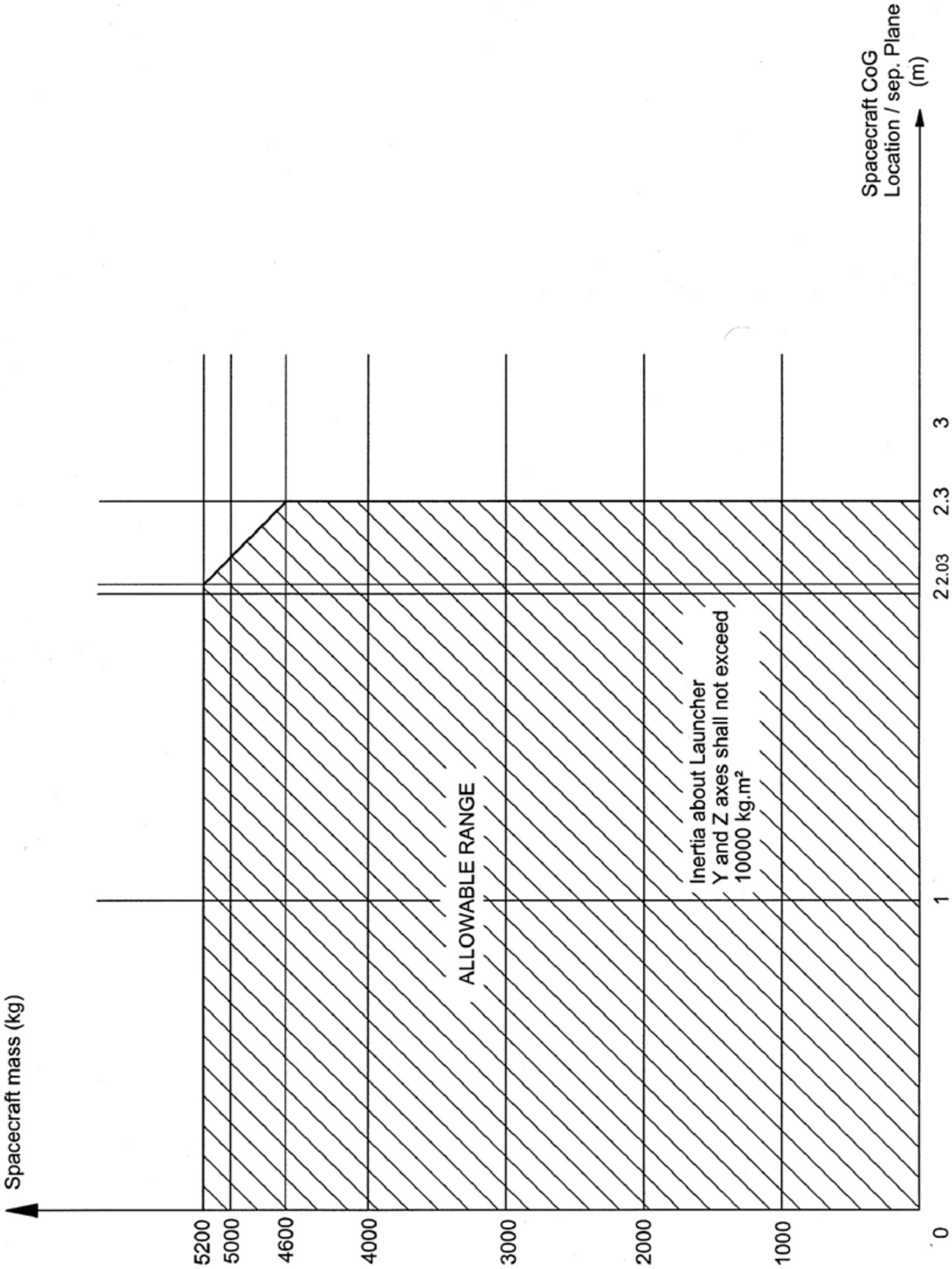


Fig. A9-1 – Limit loads of adaptor 1663SP5 at separation plane

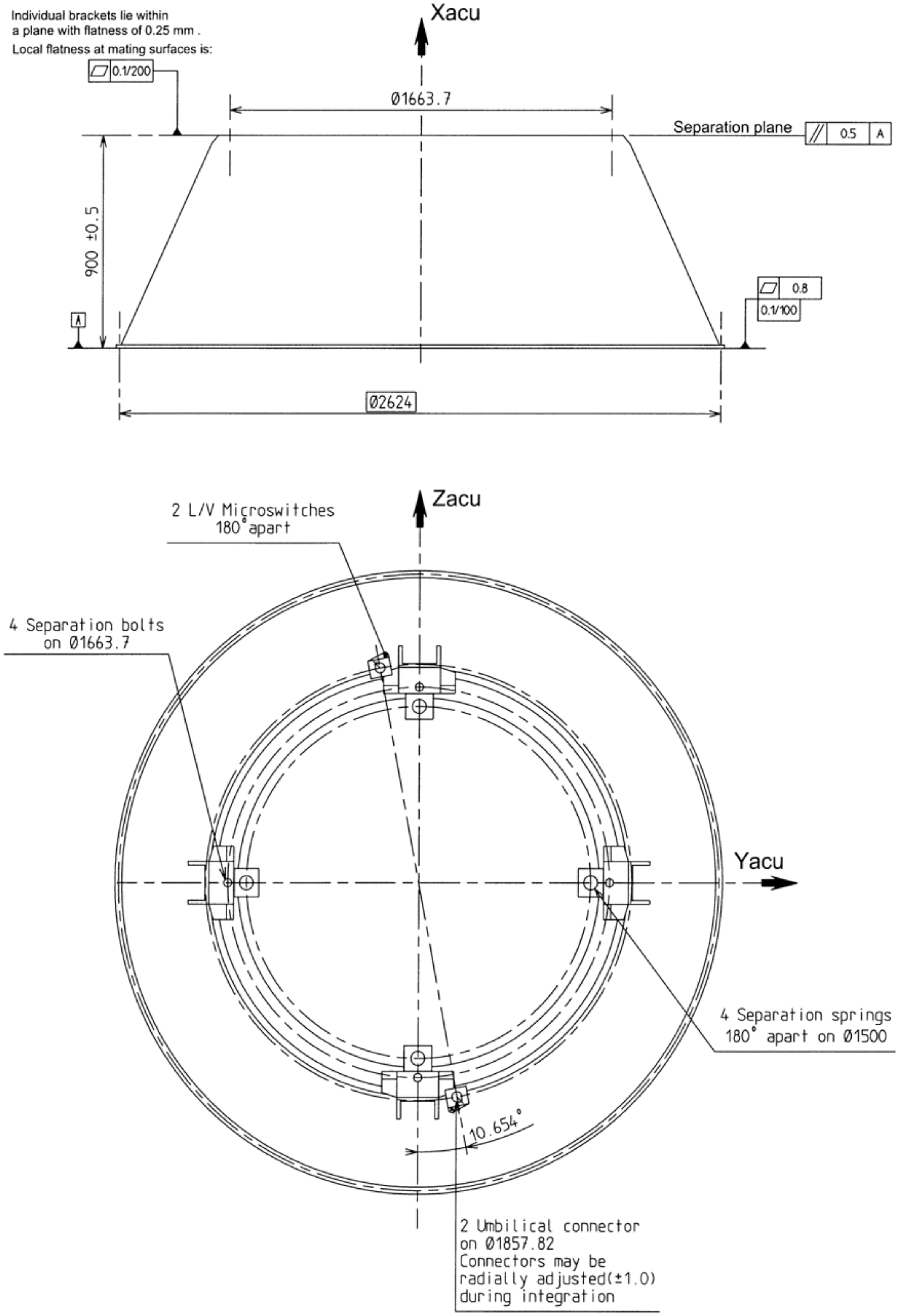


Fig. A9-2 – Adaptor 1663SP5 - General view and main characteristics

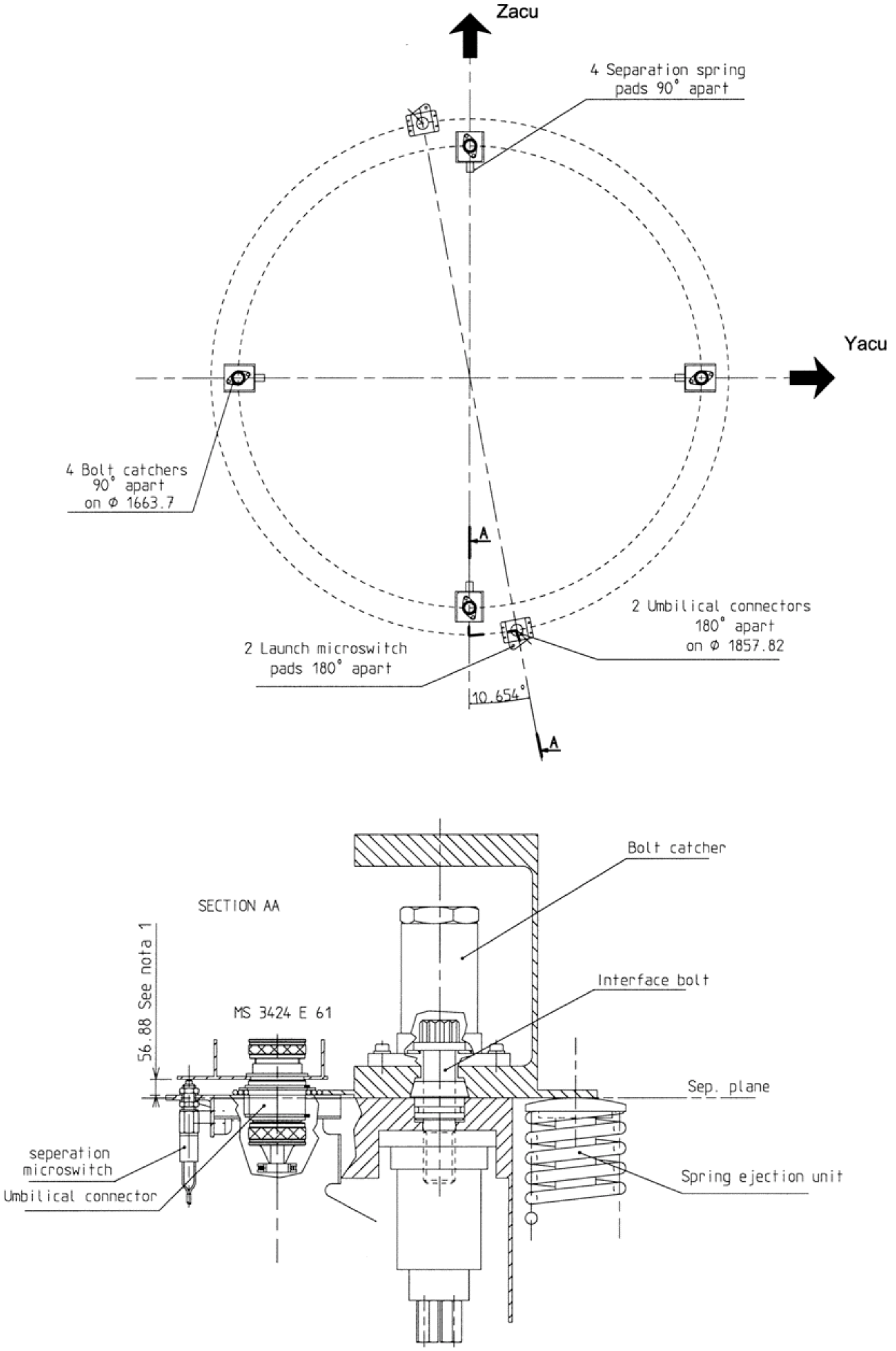


Fig. A9-3 – Adaptor 1663SP5 - Mechanical interface – Principle

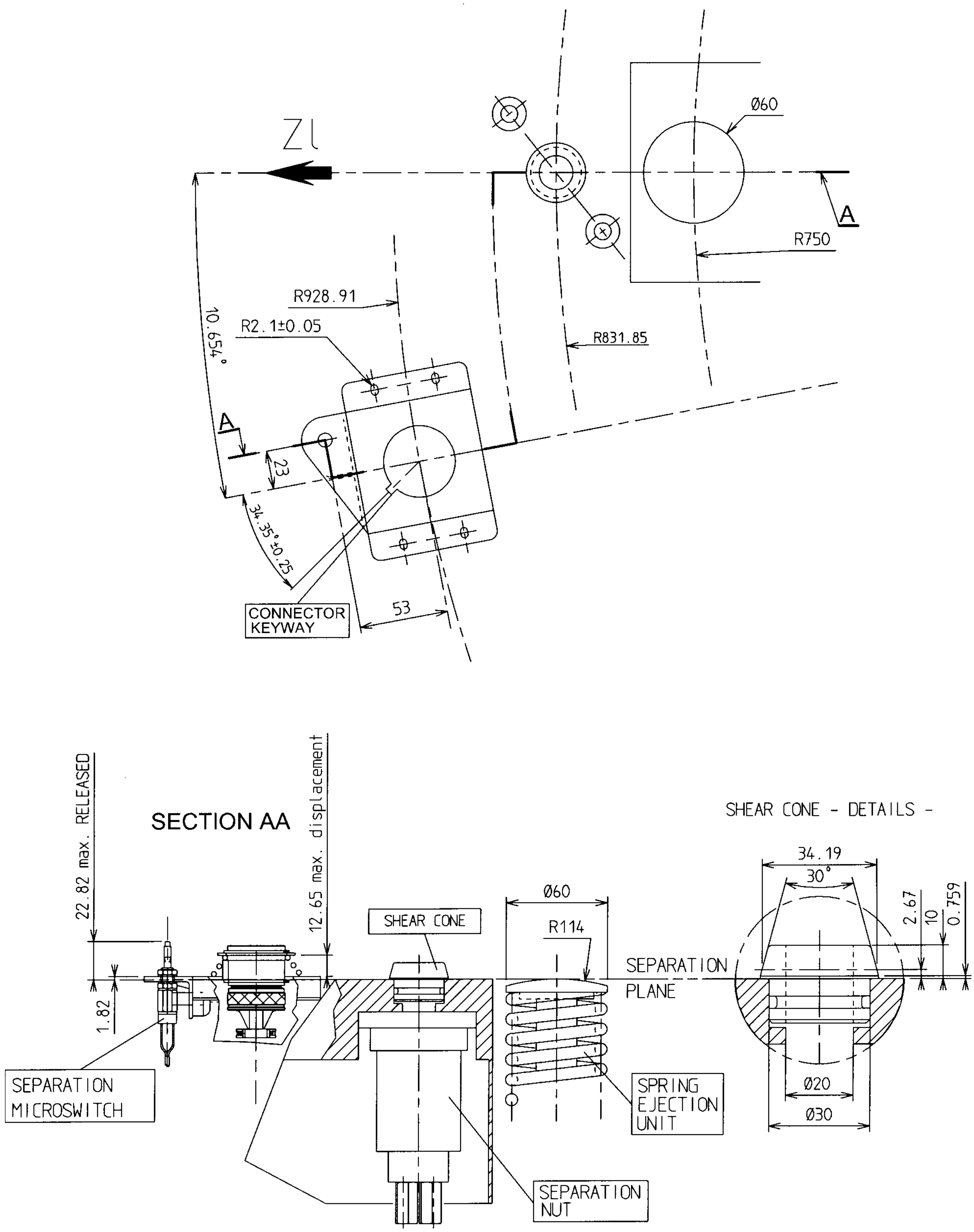
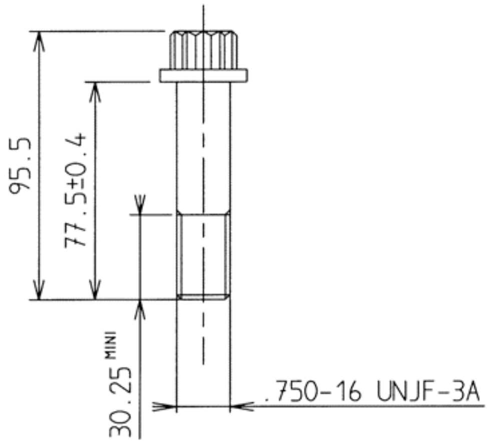
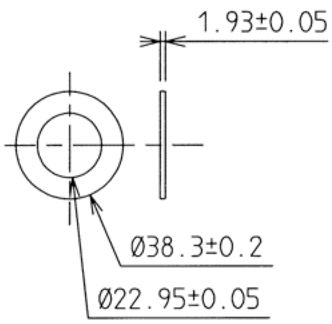


Fig. A9-4 – Adaptor 1663SP5 - Adaptor side – Interface details

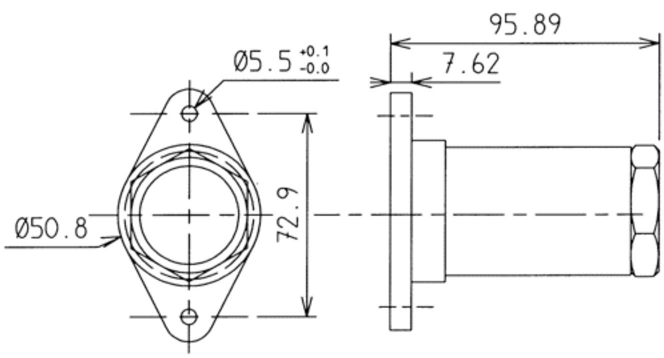
INTERFACE BOLT



SPECIAL WASHER



BOLT CATCHER



Note : These mechanical parts are supplied with adaptor.

Fig. A9-5 – Adaptor 1663SP5 – Adaptor side - Interface details

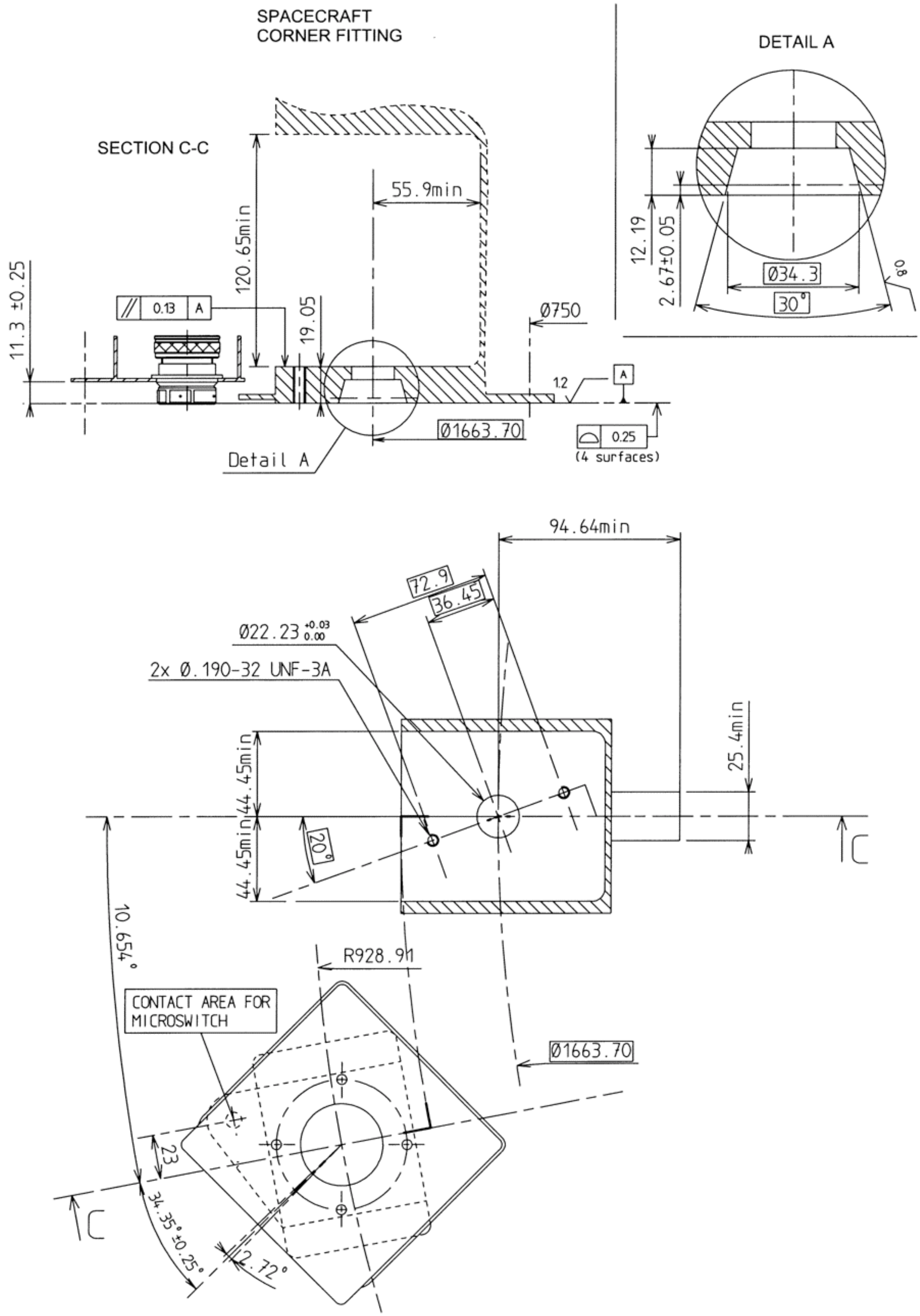


Fig. A9-6 – Adaptor 1663SP5 - Spacecraft side - Interface details

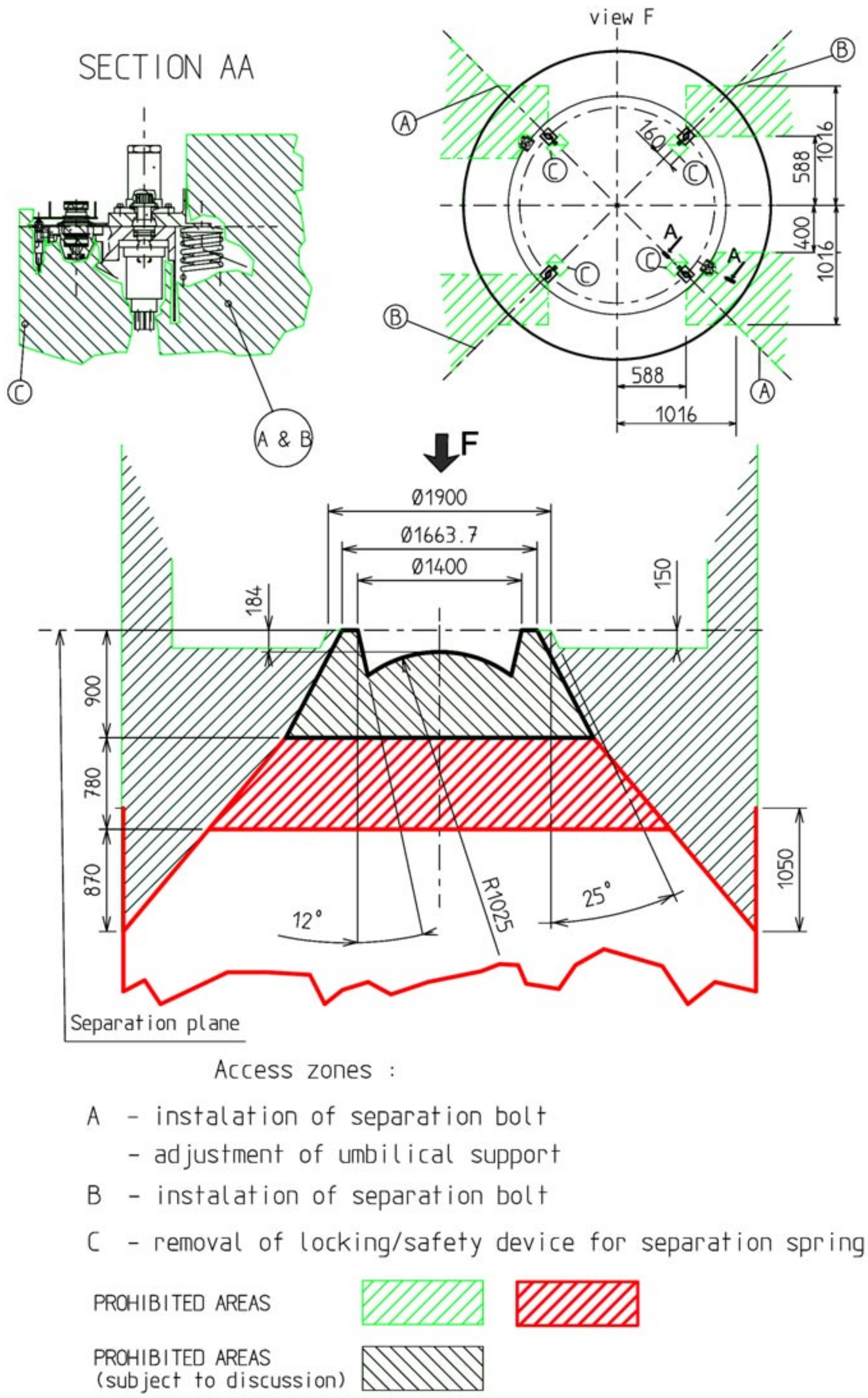


Fig. A9-7 – Adaptor 1663SP5 : Usable Volume

Adaptor 1666 V5

Annex 10

The 1666V5 spacecraft adaptor is a carbon structure in form of a truncated cone, with a diameter of 1666 mm at the level of spacecraft separation plane. It is attached to the reference plane (∅ 2624) by means of a bolted frame and provides for spacecraft separation.

The spacecraft rests on the forward frame of the adaptor and is secured by a clampband. The latter consists of a metal strip which holds in place a serie of clamps hooked on to the spacecraft and adaptor frames. 22 of the clamps comprise a shear-pin for the shear loads transmission at the interface. At separation, the band is severed in two places by a bolt cutter mounted on the adaptor, the pieces remaining captive to the adaptor.

The spacecraft is forced away from the launch vehicle by a series of actuators forming part of the vehicle and bearing on the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s. Once the clampband is fitted, each actuator exerts a force of less than 1500 N on the rear spacecraft frame. The adaptor is equipped either with external (6 max) or internal (8 max) actuators on user request.

The clampband tension does not exceed the values defined hereafter at any time, it is defined to ensure no gapping between the spacecraft and adaptor interface frames in ground and flight environment.

The 1666V5 adaptor has a mass of 145 kg.

The actual spacecraft pair of values (M_{cu}, X_G) must be such that the forces on the adaptor spacecraft interface remain within admissible limits as defined in Fig. A10-1 using the quasi-static load values indicated in paragraph 4.5.5 (chapter 4).

Figures A10-5a and A10-5b give the dimensions of the spacecraft-frame butt. Apart from correct observance of these dimensions, this frame must be manufactured in an aluminium alloy.

Umbilical connectors brackets: on the spacecraft side, the connectors brackets must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

S/C mass	**Clampband tension**	**S/C rear frame**
M $\leq$ 3500 kg	32 000 N	Refer to fig. A10-5a
3500 kg < m $\leq$ 4500 kg	38 800 N	Refer to fig. A10-5b

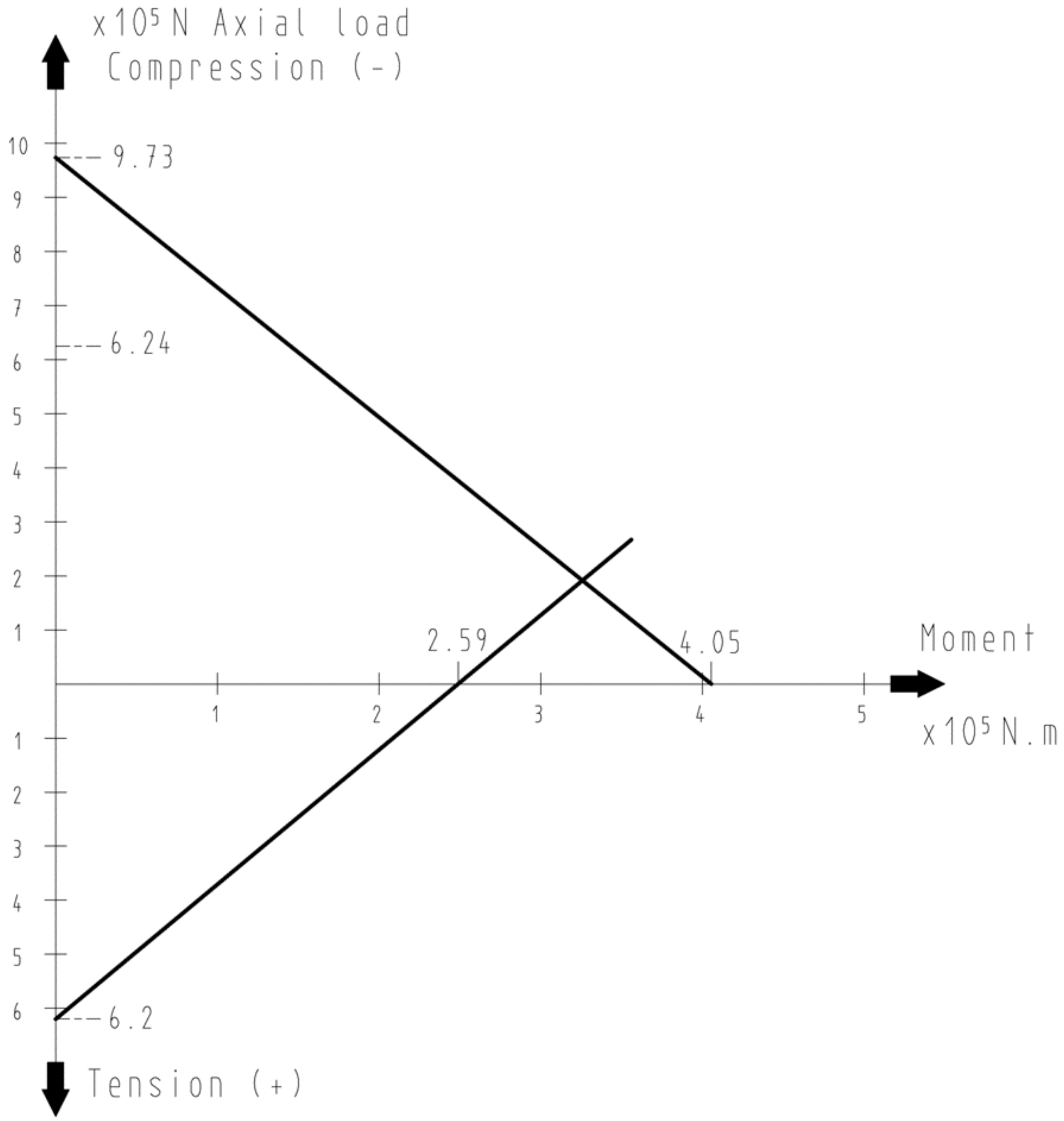
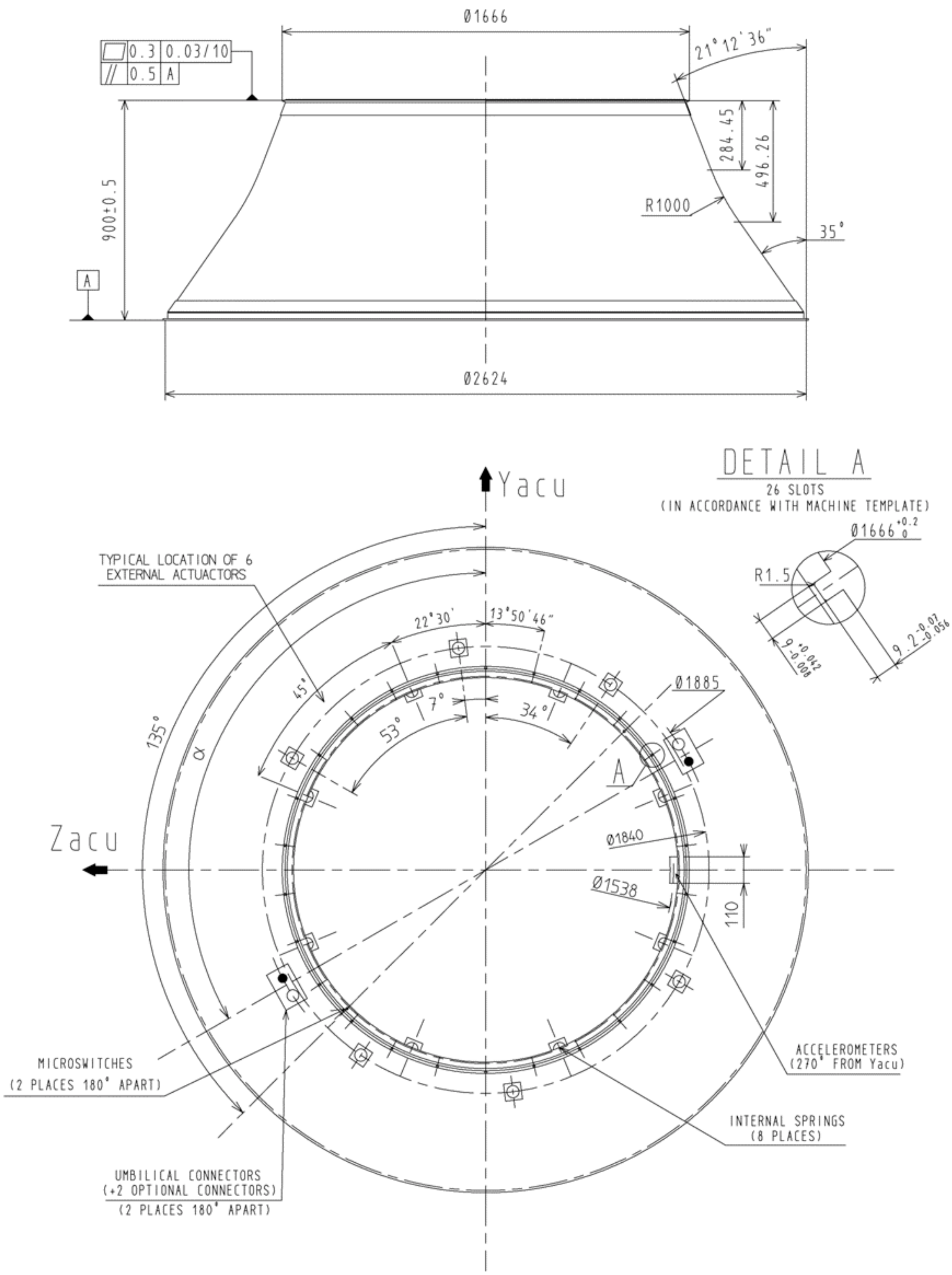


Fig. A10-1 – Limits loads of adaptor 1666V5 at separation plane



α = 120° for external actuators version and

144°55' for internal actuators version

Fig. A10-2 –Adaptor 1666V5 General view and main characteristics

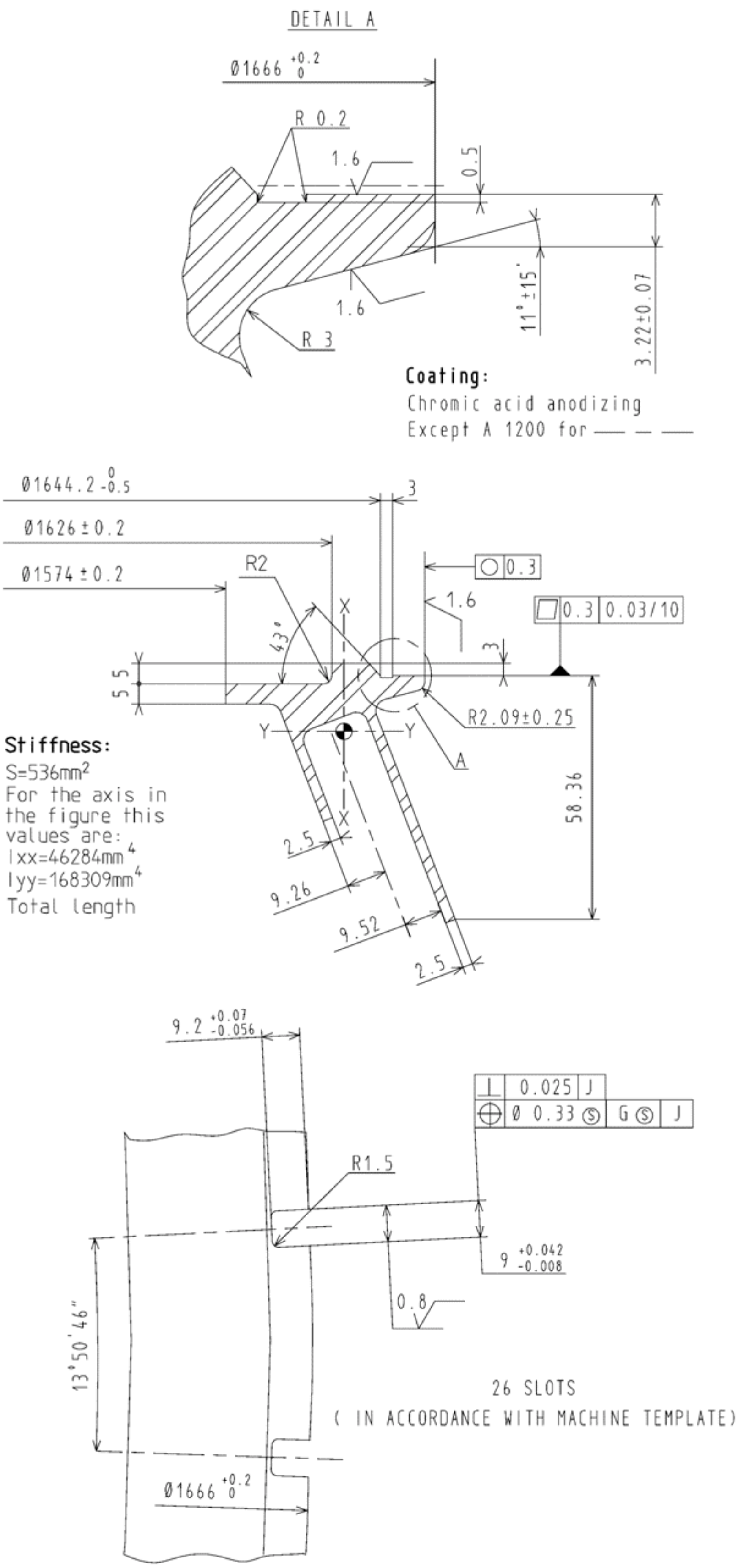


Fig. A10-3 – Adaptor 1666V5 Forward frame

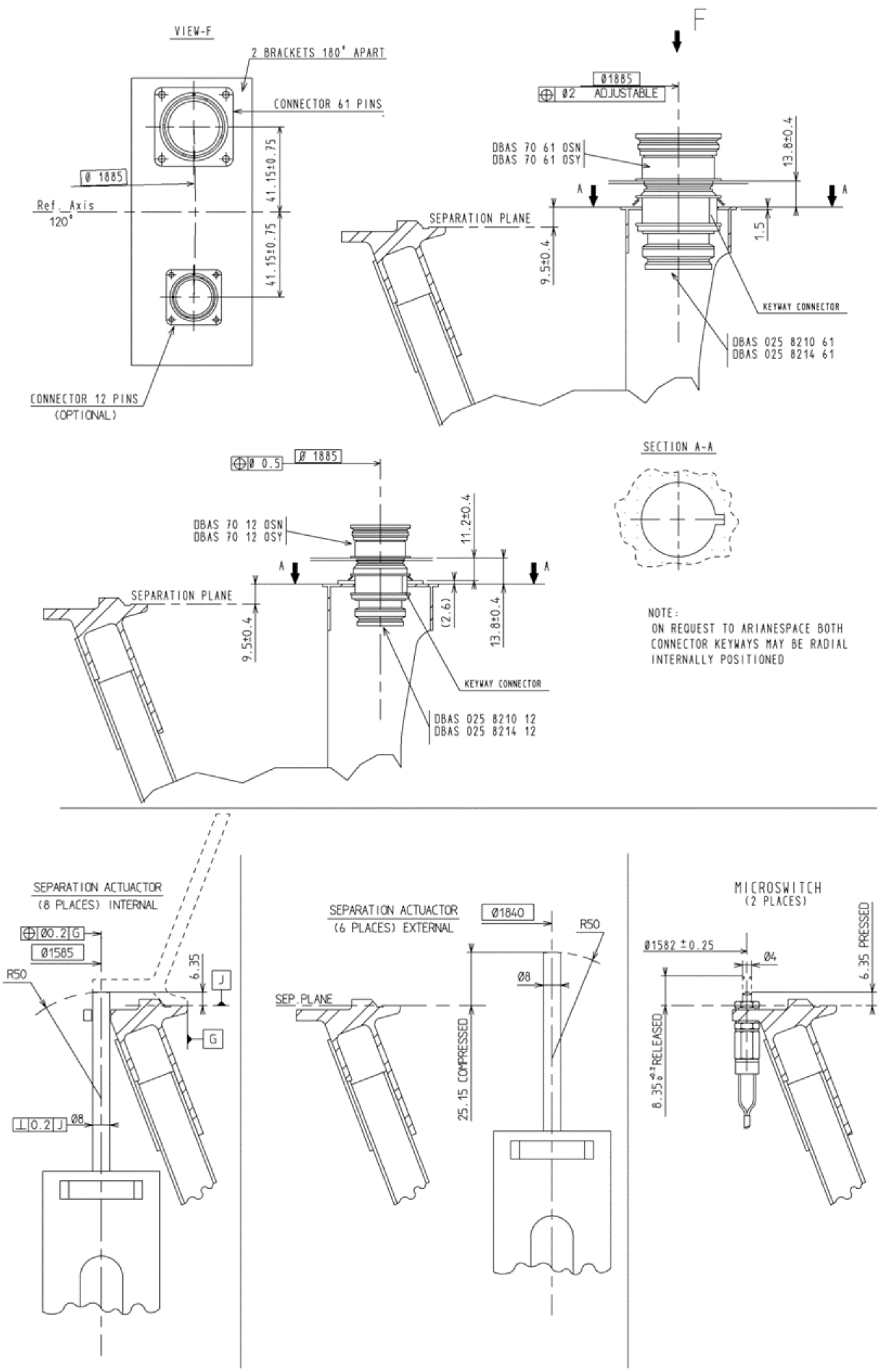


Fig. A10-4 – Adaptor 1666V5 - Mechanical interface (details)

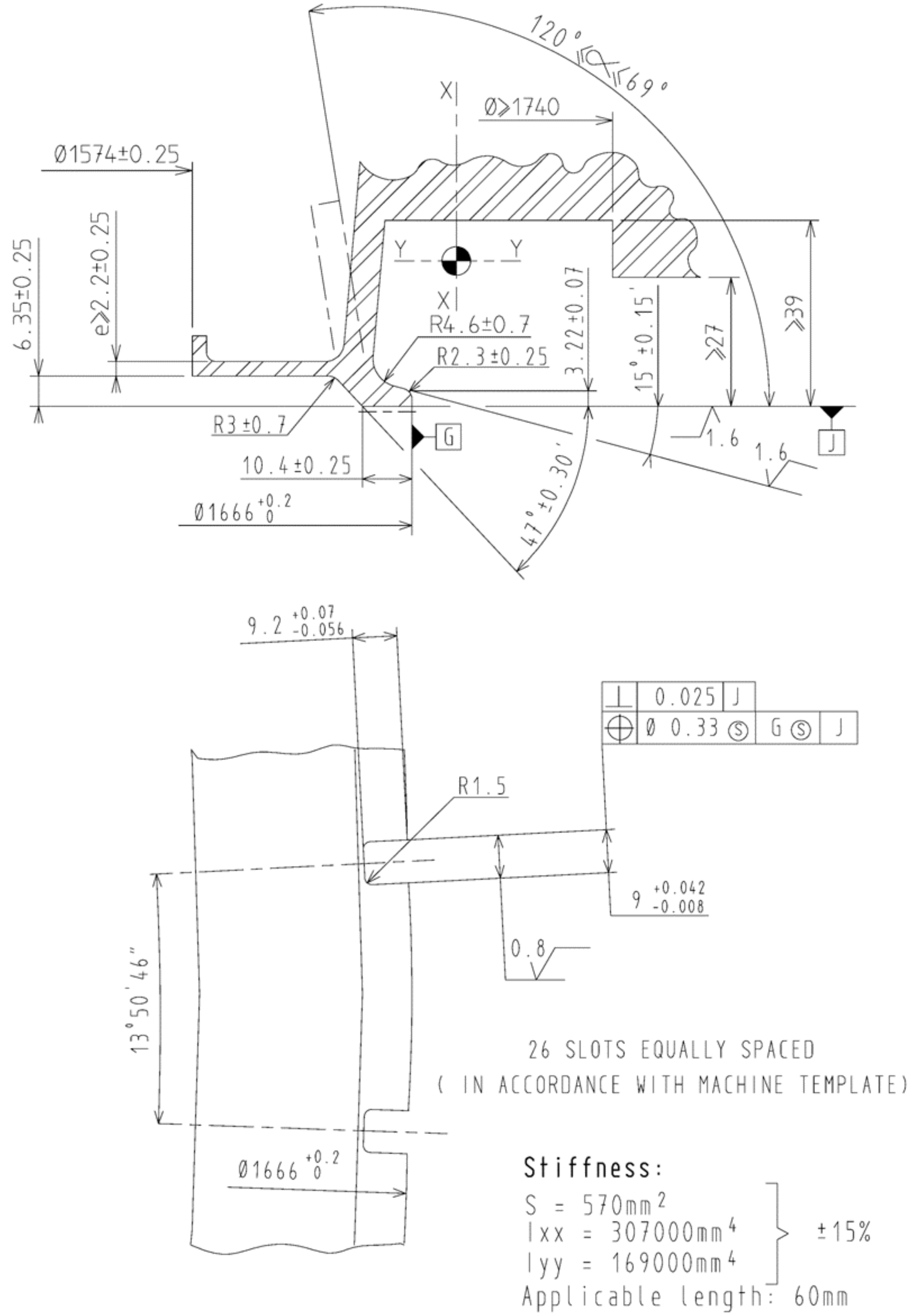


Fig. A10-5a – Adaptor 1666V5 – Spacecraft rear frame (M ≤ 3500 kg)

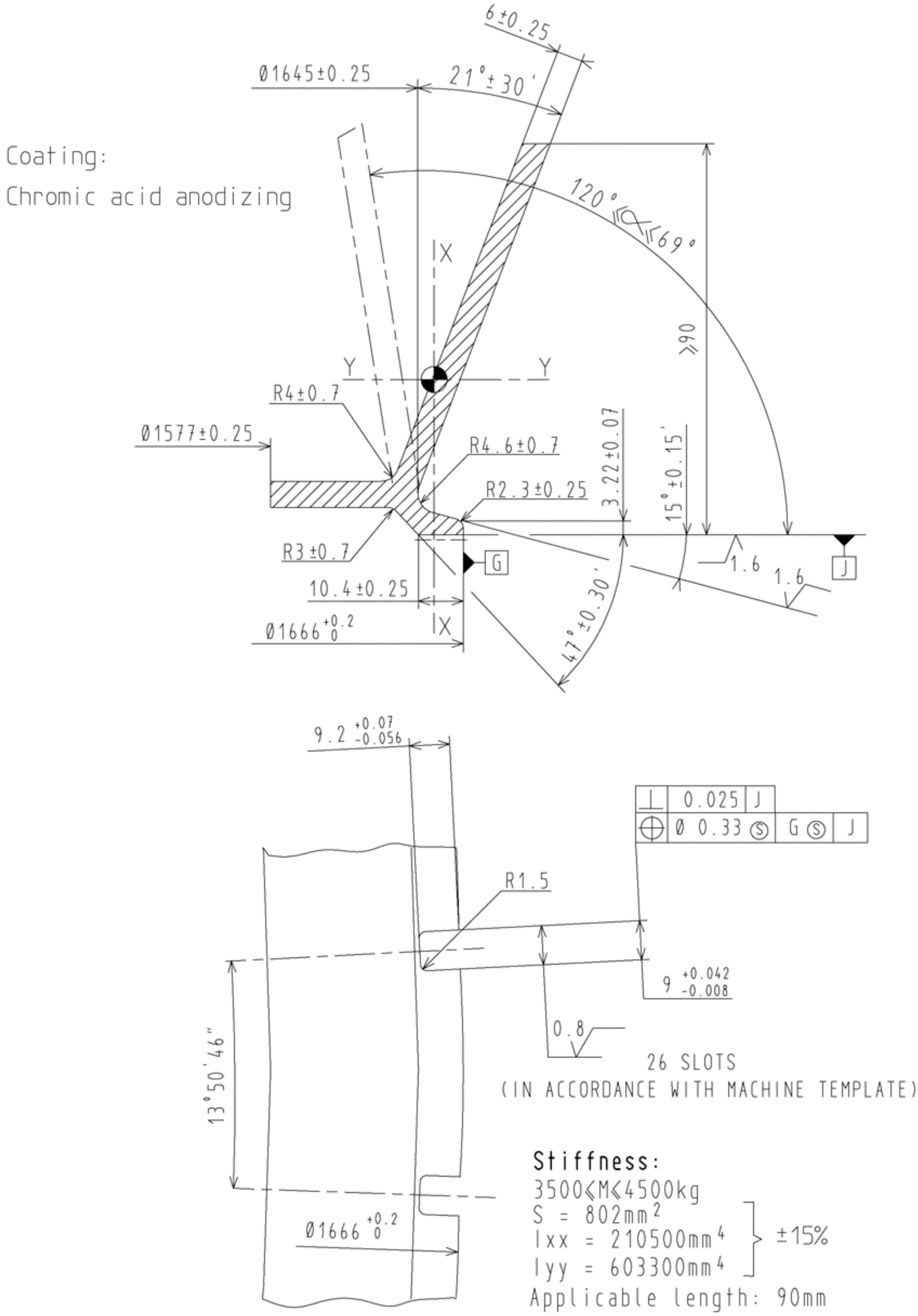


Fig. A10-5b – Adaptor 1666V5 – Spacecraft rear frame (M > 3500 kg)

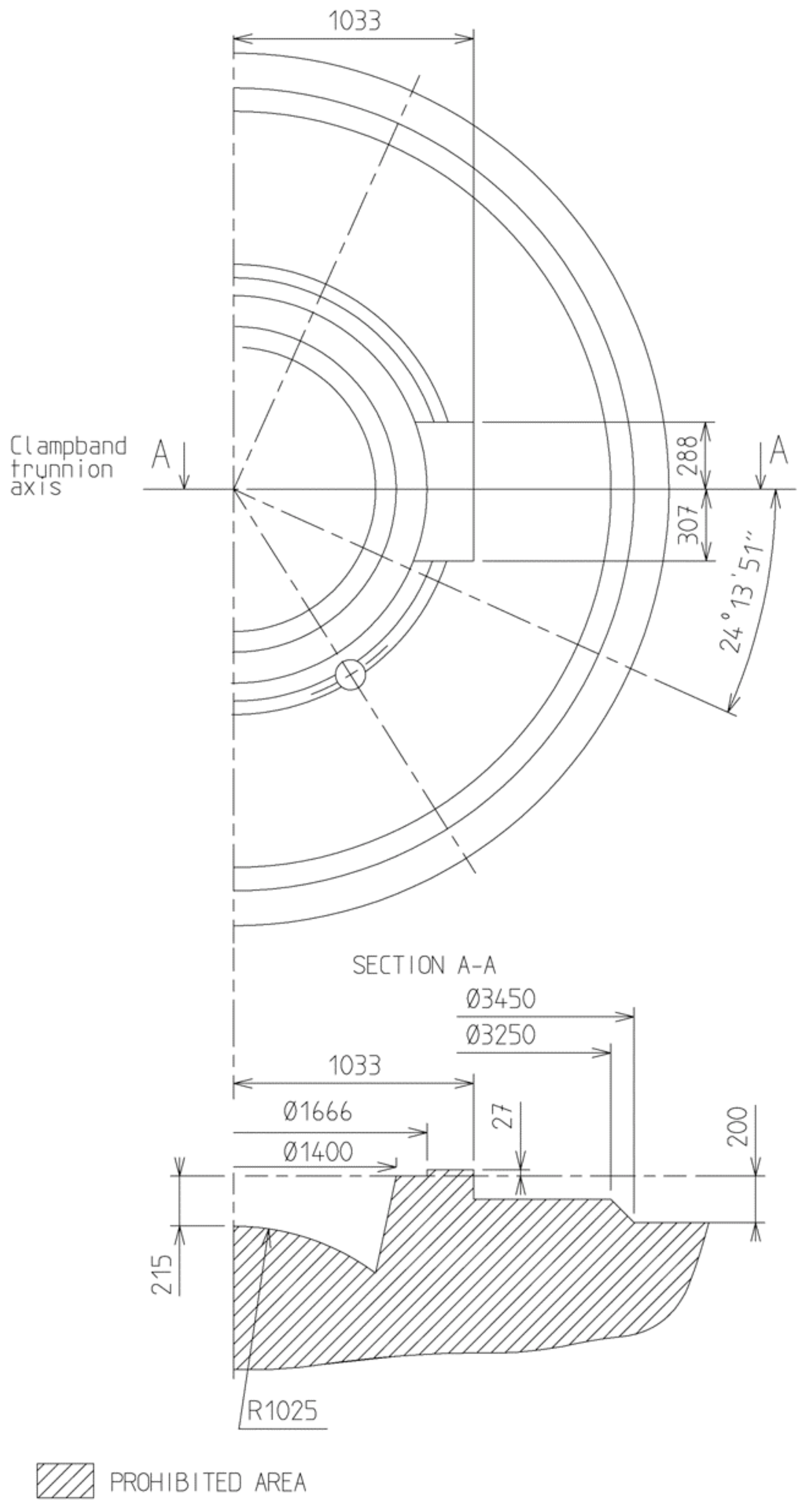


Fig. A10.-6 – Adaptor 1666V5 – Usable Volume

Adaptor 2624 — Annex 11

This 2624 adaptor is an aluminum alloy cylinder, with a diameter of 2624 mm at the level of the spacecraft separation plane. It is attached to the reference plane (∅ 2624) by a bolted connector frame, and also provides for spacecraft separation.

The actual spacecraft pair of values (Mcu, X_G) must be such that the forces on the adaptor/spacecraft interface remain within admissible limits as defined in figure A.11-1 using the quasi-static load values indicated in par 4.5.5 (chapter 4).

The spacecraft rests on the forward frame of the adaptor and is secured by a clampband. The latter consists of a metal strip which holds in place a series of clamps hooked on to the spacecraft and adaptor frames. At separation, the band is severed in two places by a bolt cutter mounted on the adaptor, the pieces remaining captive to the adaptor.

The clampband tension does not exceed 45 400 N at any time, it is defined to ensure no gapping between the spacecraft and adaptor interface frames in ground and flight environment.

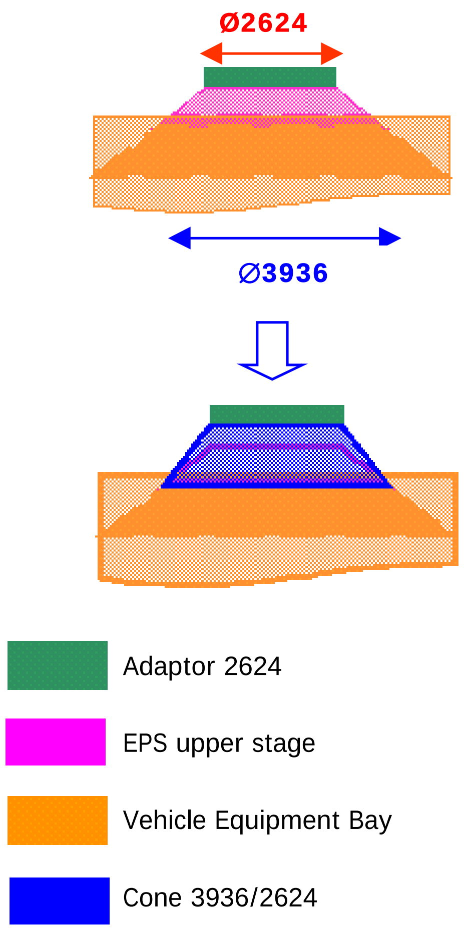
The spacecraft is forced away from the launch vehicle by a series of actuators (4 to 12) forming part of the vehicle and bearing on the spacecraft rear frame. The relative velocity between the adaptor and the spacecraft is about 0.5 m/s. Once the clampband is fitted, each actuator exerts a maximum force of 1400 N on the rear spacecraft frame.

The 2624 adaptor has a mass of 98 kg. When mounted on the EPS , a stiffening plate (USF) is necessary. The mass of the USF is 50 kg
Figure A.11-4 gives the dimensions of the spacecraft-frame butt. Apart from correct observance of these dimensions, this frame must be manufactured in an aluminum alloy.

The angular positioning of the spacecraft on the adaptor is ensured by alignment of engraved marks on the interfacing frames.

Umbilical connectors bracket : on the spacecraft side, the connector bracket must be stiff enough to prevent any deformation greater than 0.5 mm under the maximum force of the connector spring.

For a launch on the EPS upper stage, satellites which mass and center of gravity are lower than 6500 kg at 2,5 m are mated directly on the EPS (see usable volume on fig. A11-6). For satellites which mass and center of gravity are greater than 6500 kg and 2,5 m, a raising cone 3936/2624 could be required.This cone is 1m high, its mass is 230 kg, it covers the EPS upper stage and it is mounted on ∅3936. It leads to the usable volume given in figure A11-7.



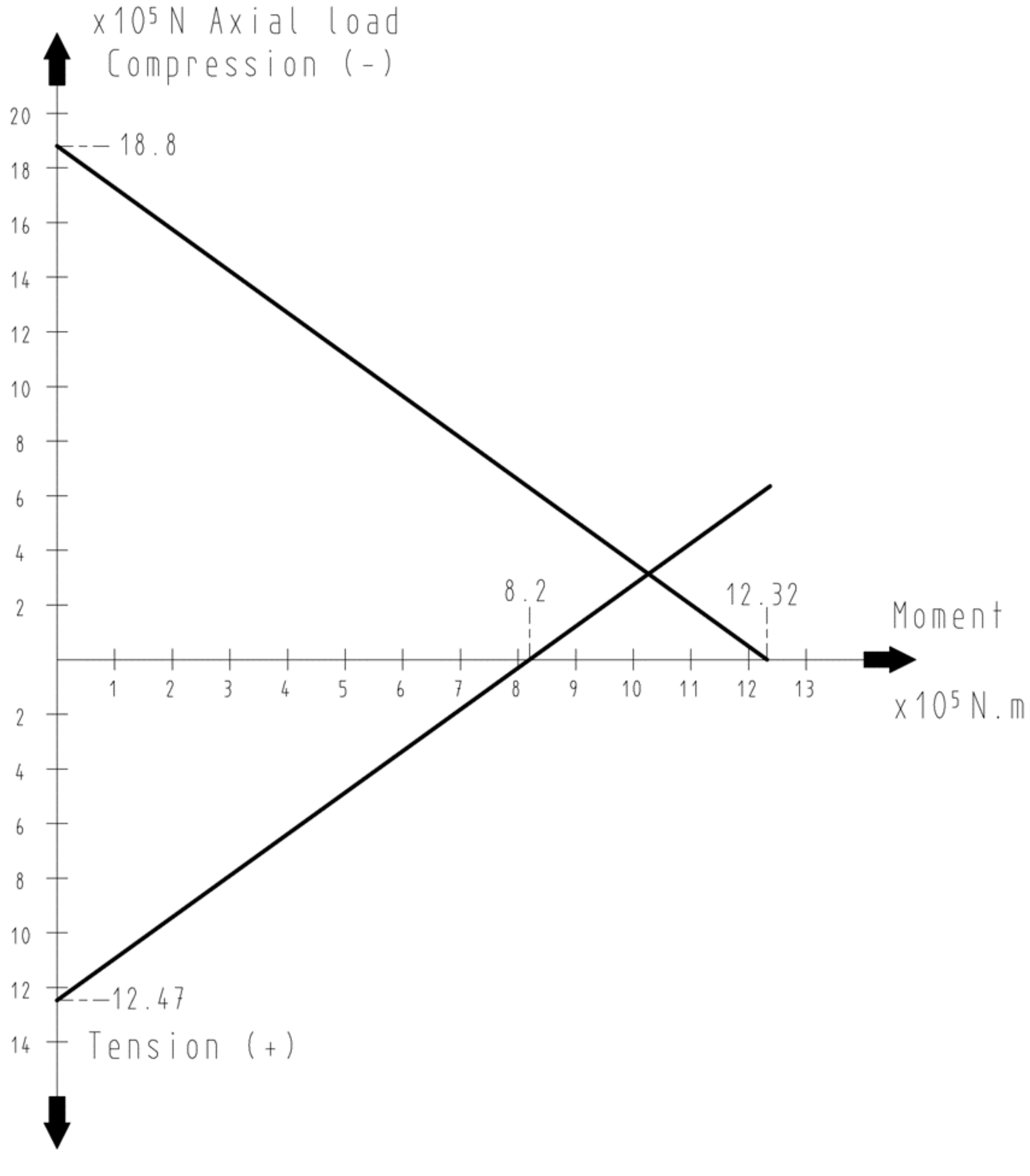


Fig. A11-1 - Limit loads of adaptor 2624

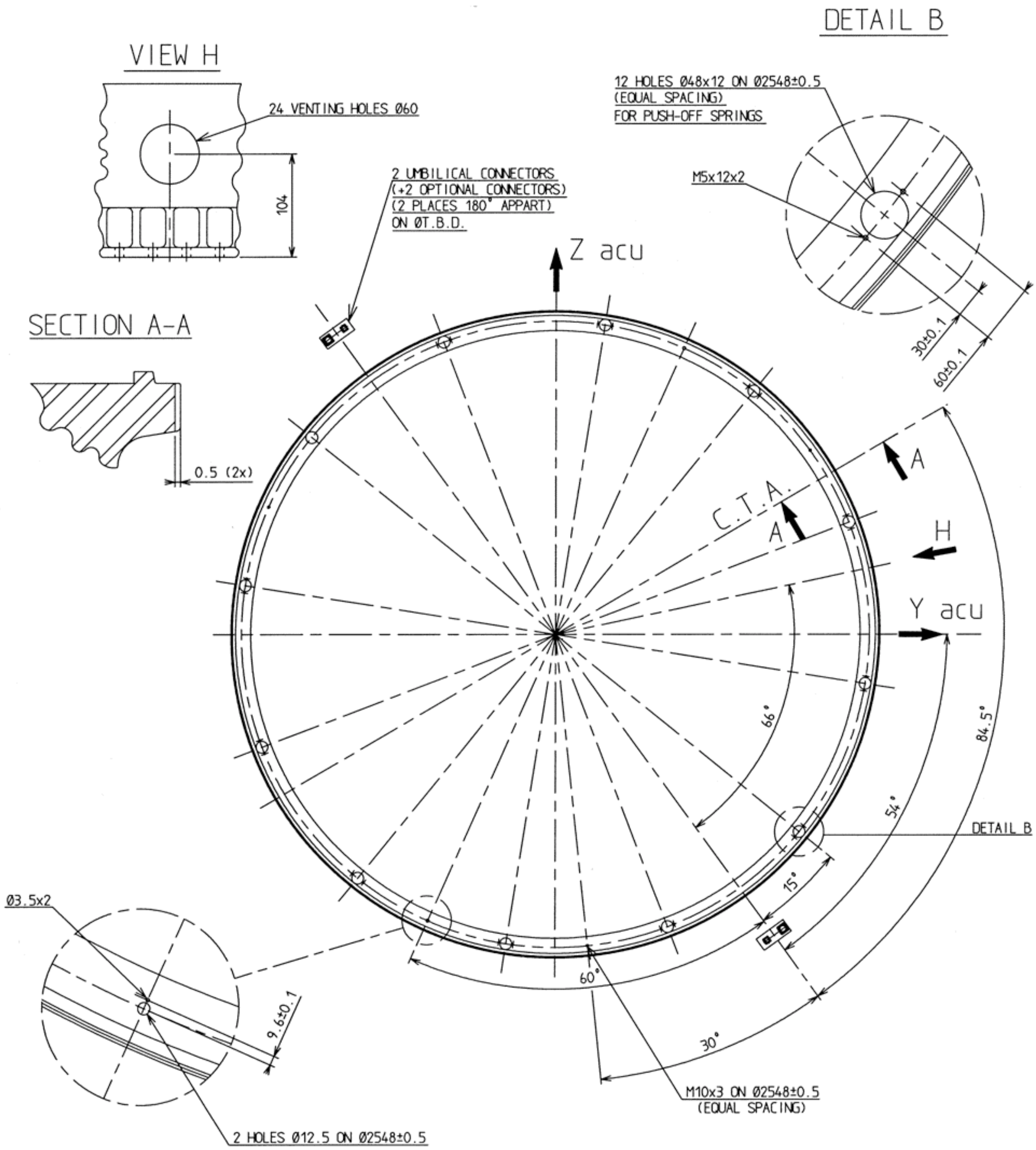


Fig. A11-2 – adaptor 2624 General View and main characteristics

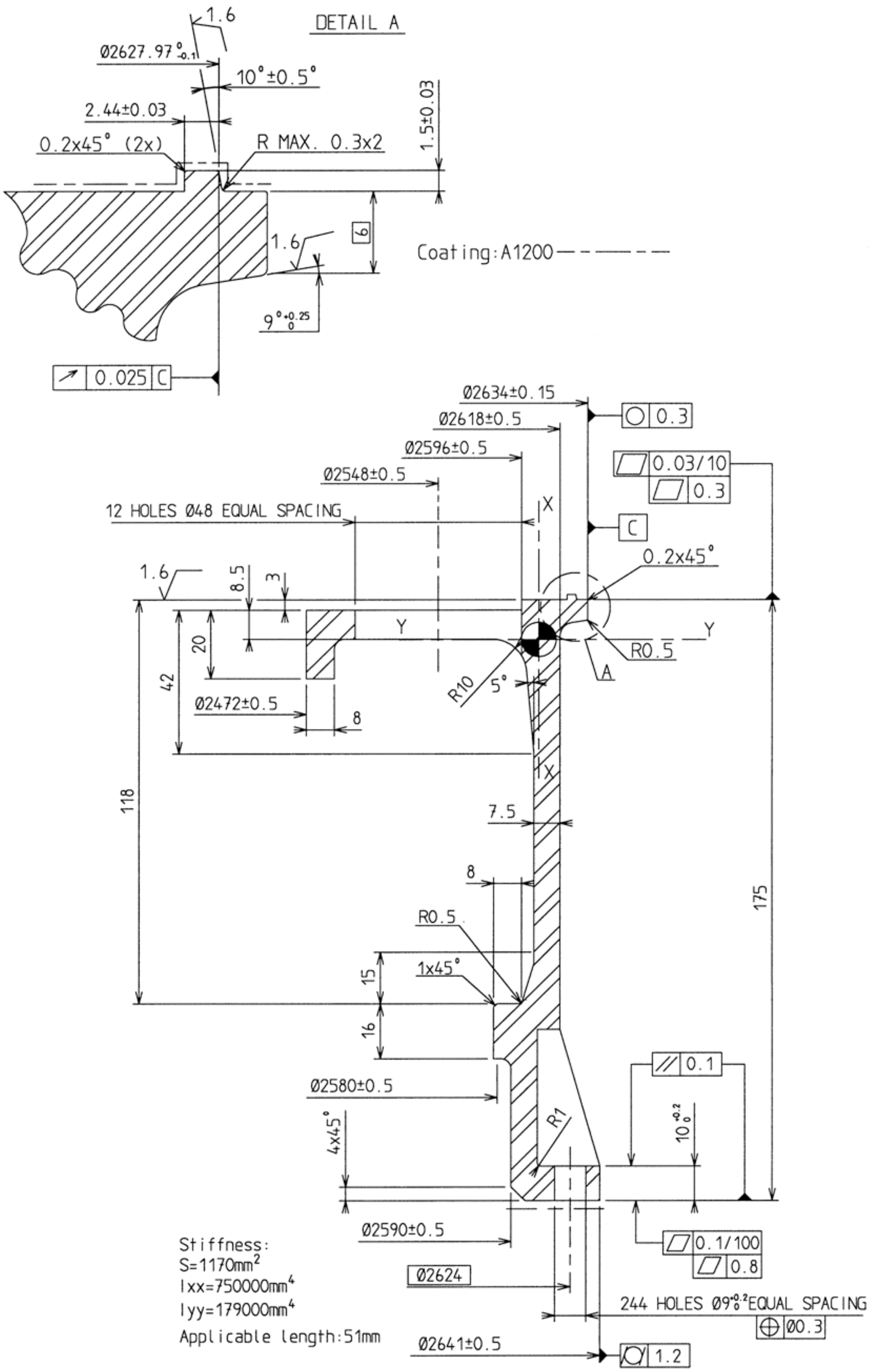


Fig. A11-3 - Adaptor 2624 interface

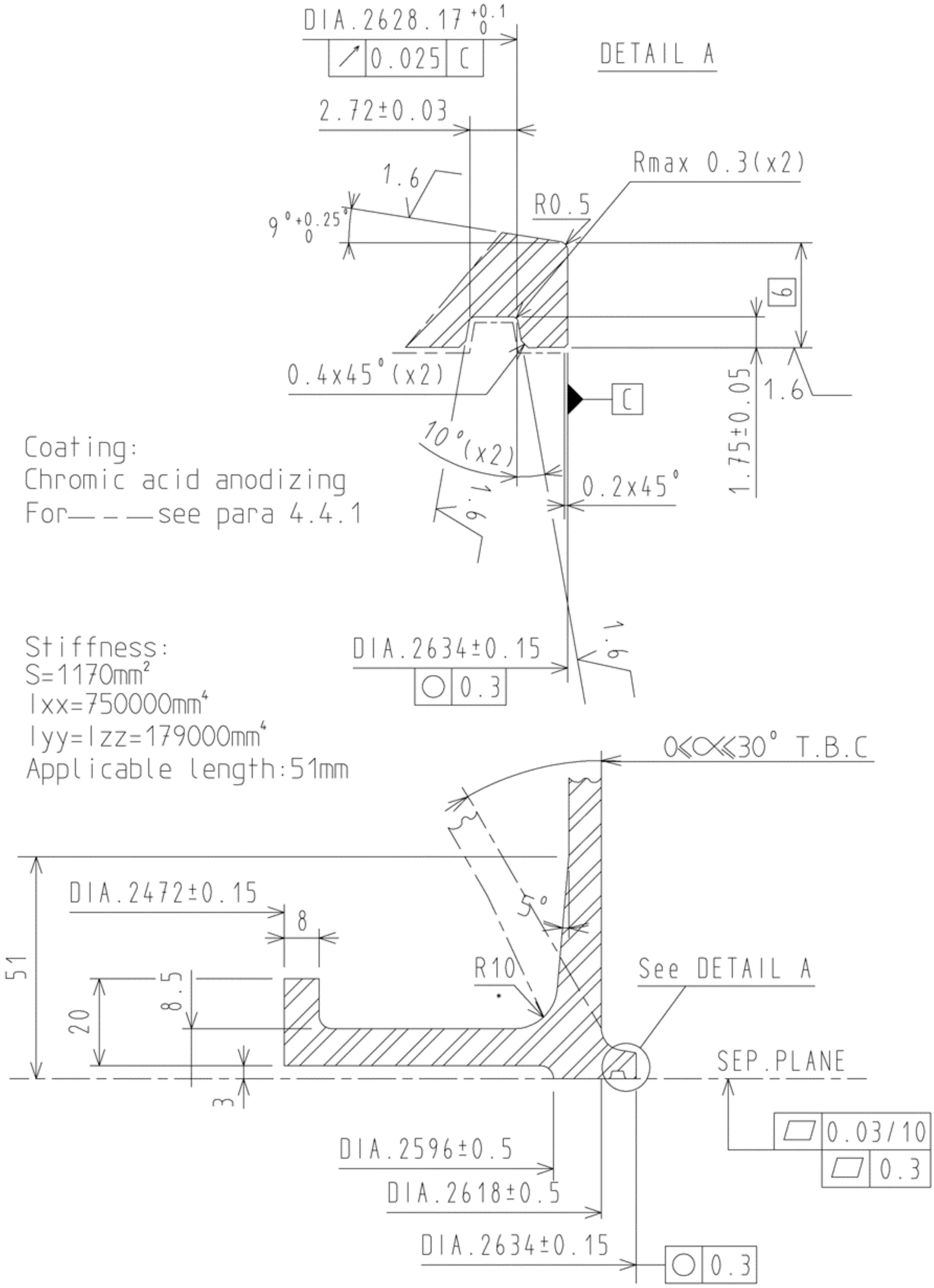
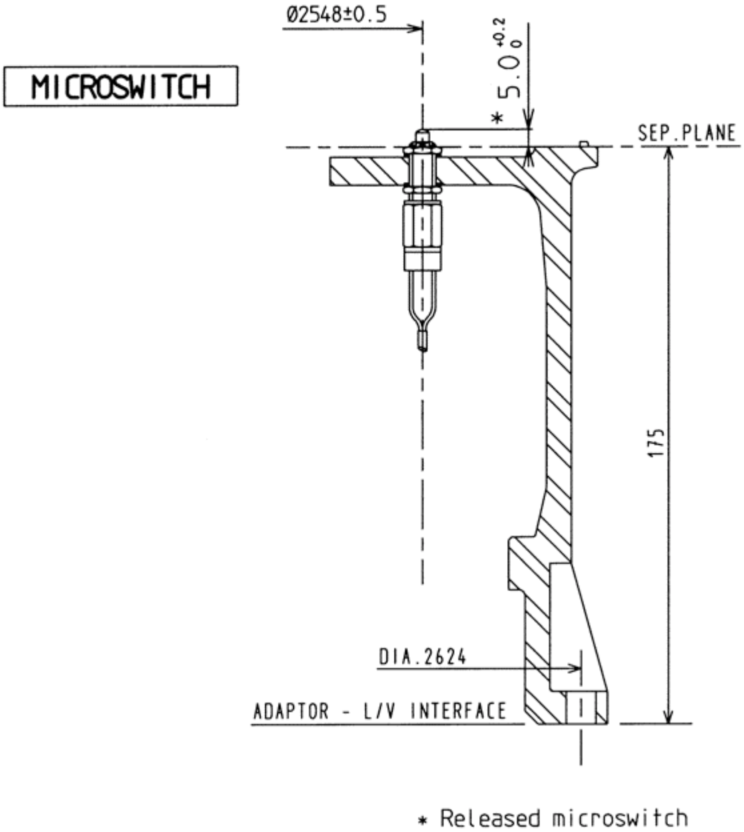


Fig. A11-4 – Adaptor 2624 Spacecraft rear frame



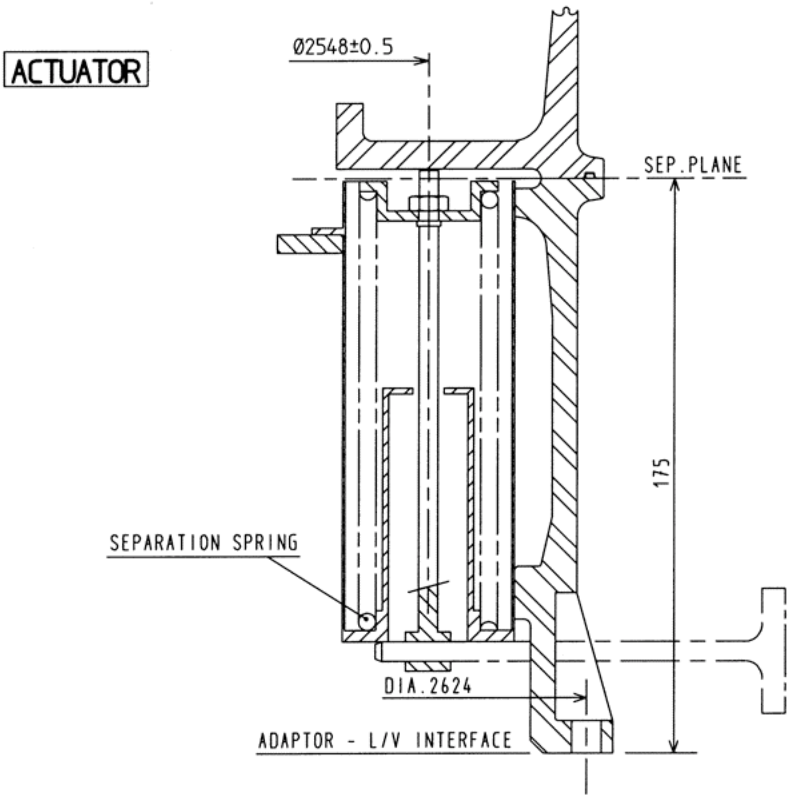


Fig. A11-5 - Adaptor 2624 Mechanical Interface (details)

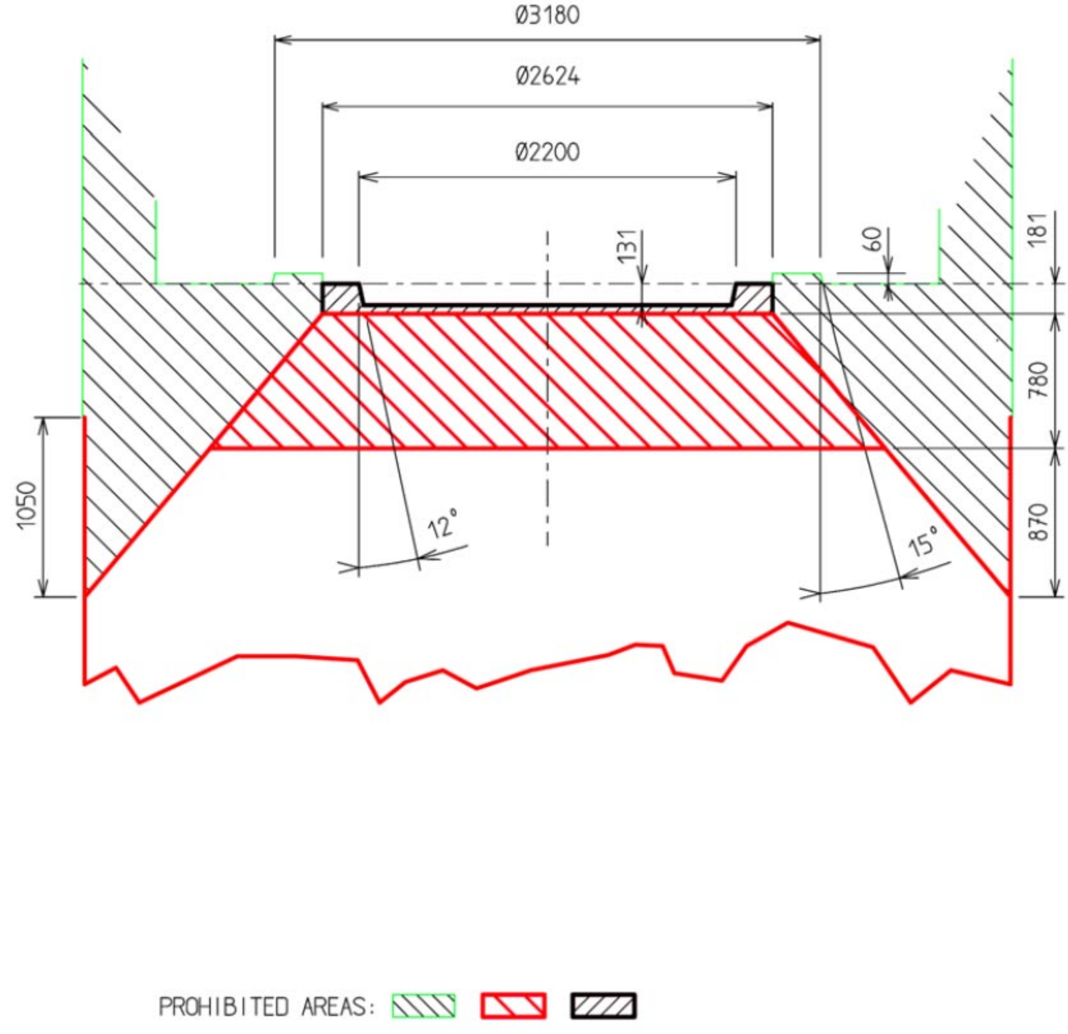


Fig. A11-6 – Adaptor 2624 Usable Volume

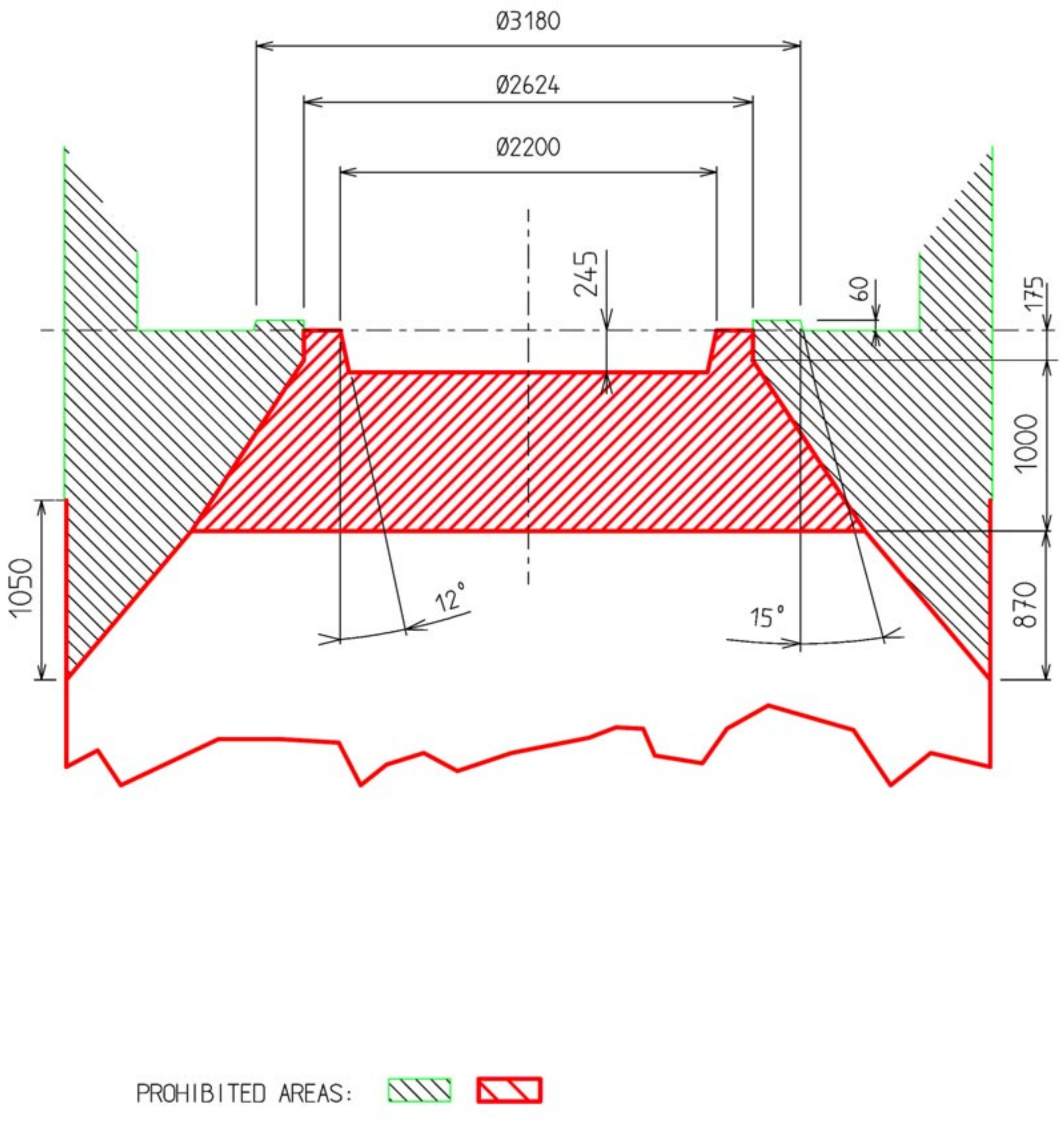


Fig. A11-7 – Adaptor 2624 Usable Volume with cone 3936/2624

Dispensers

Annex 12

12.1 : Introduction

Multiple launch configurations, in particular for constellations deployment may imply the use of a multiple payload carrying structure.
Arianespace has acquired the expertise of multiple payload launch and separations through the auxiliary payload launch service, well adapted to scientific, industrial research and university programs (up to seven satellite injected at a time during an ARIANE 4 mission).
Based on its experience and on the expertise of the European industry developing already such devices, ARIANESPACE proposes as part of its launch service the use of its dispensers. The Ariane dispenser carries the satellites and provides the separation system. It remains mated to the launcher after the payload separations.

Two conceptual design are proposed :

- Dispenser with central tube (boom dispenser), see figure 12.1 : this equipment can be used on the single launch configuration or on the dual launch configuration as well inside, than on top of SPELTRA. The tube diameter is optimized in order to maximize the volume offered to the payload and the number of satellites. The spacecraft is attached along one of its longitudinal faces on this structure.
- Dispenser with structural plate (platform dispenser), see figure 12.2 : this structure receives one adapter or adaptation per spacecraft . The spacecraft is mated through its base.

Definition of the separation system and interfaces are coordinated with the user.
Such device being mission dependant, customers wishing to perform such a launch are requested to contact ARIANESPACE to optimize a pre-design of the satellite, based on ARIANESPACE experience and ARIANE constraints.

12.2 : Environment specificities

NA

12.3 : Design and dimensioning requirement specificities

NA

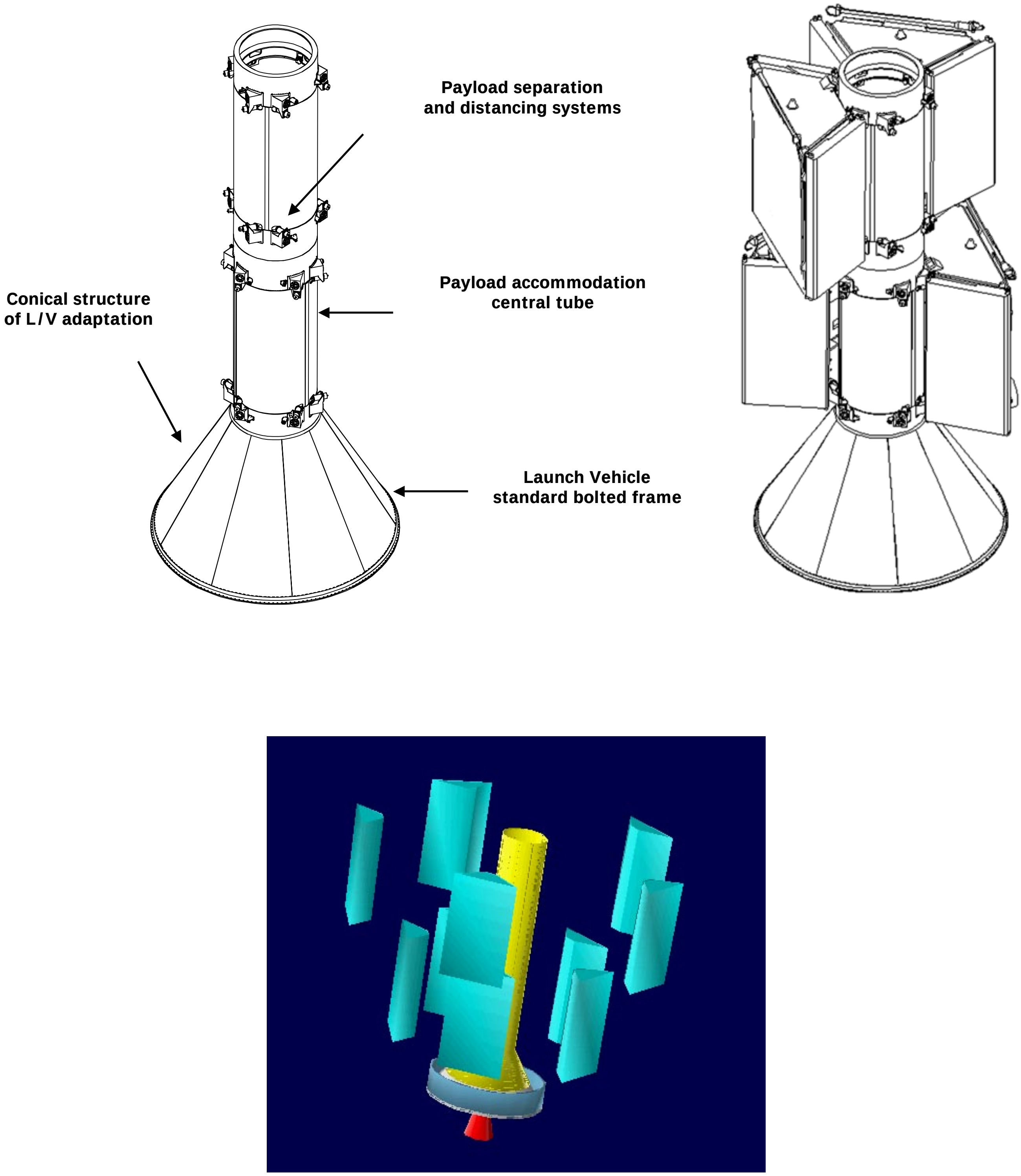
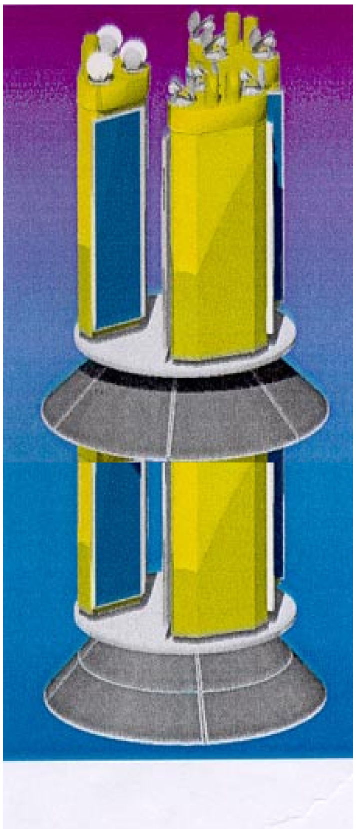
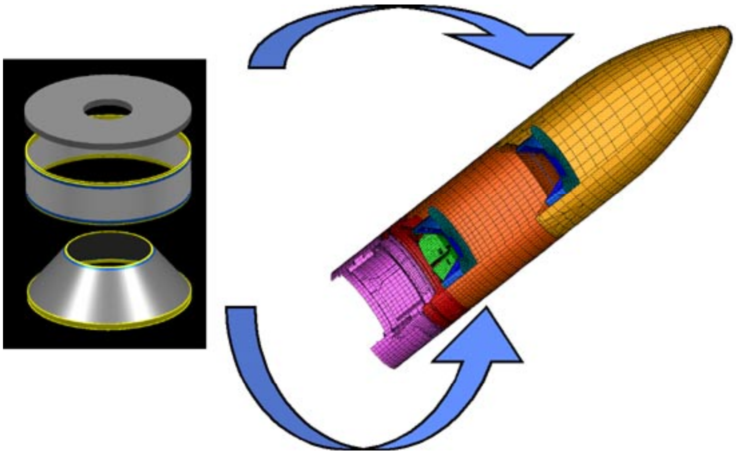


Fig 12.1 : ARIANE multipurpose boom dispenser





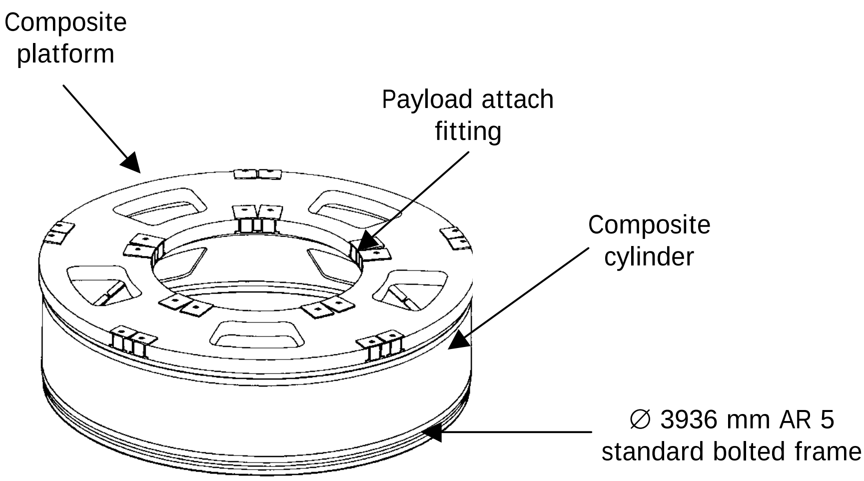


Fig. 12.2 : Multipurpose platform dispenser